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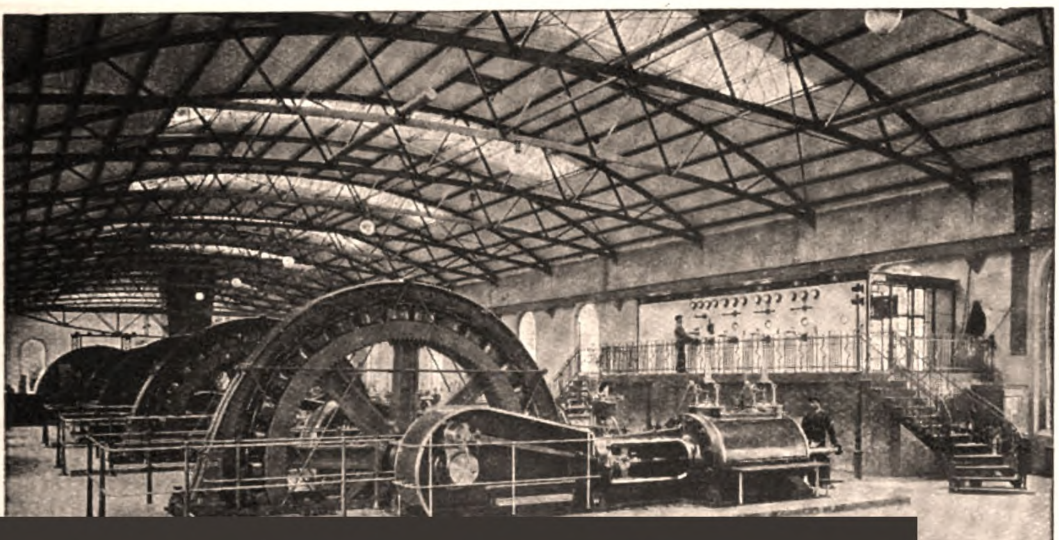

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The
Electrical Magazine

THEO. FEILDEN, EDITOR-IN-CHIEF.

E. DINSDALE PHILLIPS, ACTING EDITOR.

INDEX TO VOL. VII.

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(Each Section is Indexed separately, and there is no cross Indexing between Sections.)

The World's Electric Progress.

ADVICE, Good, 308
Apprenticeship, Engineering, 250
Association, Popularising Electricity in the U.S.A., The Co-operative Electrical Development, 3
Association, The National Electrical Manufacturers', 252
BOLTON's Electrical Progress, 361
Business, Confidence in, 363
CHANNEL Tunnel, The, 6
City Tramway Obsolete? Is the, 249
Colonial Postage Reform, 119, 251
Collieries, Electric Power in, 59
Colliery Number, 117
Commercial Motor Vehicles, 120
Confidence in Business, 363
Co-operative Electrical Development Association, Popularising Electricity in the U.S.A., The, 3
DEVELOPMENT Association, Popularising Electricity in the U.S.A., The Co-operative Electrical, 3
EFFICIENCY, Individualism and, 62
Electric Power in Collieries, 59
Electric Power in Textile Factories, 305, 361
Electrical Development Association, Popularising Electricity in the U.S.A., The Co-operative, 3
Electrical Manufacturers' Association, The, 252
Electrical Progress, Bolton's, 361
Electricity in the U.S.A., The Co-operative Electrical Development Association, Popularising, 3
Electricity, Medical, 308
Engines, Large Gas, 61
Engineering Apprenticeship, 250
Engineering Fashions, 59
Engineering, Illuminating, 60
Enterprise in Journalism, 2
Evil of Trades Unions, The, 117
FACTORIES, Electric Power in Textile, 305, 361
Fashions, Engineering, 59
Filaments, The Preparation of Tungsten, 306
Frosted Lamp, The, 306
GAS ENGINES, Large, 61
Good Advice, 308
ILLUMINATING Engineering, 60
Individualism and Efficiency, 62
Industrial, Power Problem, The, 5
Industry, A Progressive, 118
Insurance and the Rating of Machines, 307
JOURNALISM, Enterprise in, 2
LAMP Situation, The New, 61
Lamp, The Frosted, 306
Large Gas Engines, 61
Light, The Moore, 362
MACHINES, Insurance and the Rating of, 307
Manufacturers' Association, The National Electrical, 252
Medical Electricity, 308
Moore Light, The, 362
Motor Vehicles, Commercial, 120
NATIONAL Electrical Manufacturers' Association, The, 252
New Lamp Situation, The, 61
Number, Colliery 117
OBSOLETE? Is the City Tramway, 249
POPULARISING Electricity in the U.S.A., The Co-operative Electrical Development Association, 3
Postage Reform, Colonial, 119, 251
Power in Collieries, Electric, 59
Power Problem, The Industrial, 5
Power in Textile Factories, Electric, 305, 361
Preparation of Tungsten Filaments, The 306
Preserving, Wood, 364
Problem, The Industrial Power, 5
Progress, Bolton's Electrical, 361
Progressive Industry, A, 118
Prospect 1906-1907, Retrospect and, 1
RATING of Machines, Insurance and the, 307
Reform, Colonial Postage, 119, 251
Retrospect and Prospect, 1906-1907, 1
SITUATION, The New Lamp, 61
TEXTILE Factories, Electric Power in, 305, 361
Trade, Turkish, 252
Trades Unions, The Evil of, 117
Tramway Obsolete? Is the City, 249
Tungsten Filaments, The Preparation of, 306
Tunnel, The Channel, 6
Turkish Trade, 252
UNIONS, The Evil of Trades, 117
U.S.A., The Co-operative Electrical Development Association, Popularising Electricity in the, 3
VEHICLES, Commercial Motor, 120
WOOD Preserving, 364

Power.

AUTOMATIC Electric Pumps for Railway Tank Supply, 9
COPPER Production, Electric Power in, 10
DOCKS, Electric Pumping for, W. C. Mountain, 253
Douglas, C. E., Large Gas Power Plants, 63
ELECTRICAL Fire Engines, 366
Electric Power in Copper Production, 10
Electric Power, Progress in, 7
Electric Pumping for Docks, W. C. Mountain, 253
Electric Pumps for Railway Tank Supply, Automatic,
Electric-Hydraulic Excavating, 317
Engines, Electrical Fire, 366
Excavating, Electro-Hydraulic, 317
FERRO-Concrete Poles, Machine-made, 365
Fire Engines, Electrical, 366
GAS Power Plants, Large, C. E. Douglas, 63
HIGH Tension Transmission, Very, 9
INDUCTION Motors, The Starting of Single-Phase, 316
LARGE Gas Power Plants, C. E. Douglas, 63
MACHINE-made Ferro-Concrete Poles, 365
Motors, The Starting of Single-Phase Induction, 316
Mountain, W. C., Electric Pumping for Docks, 253
OVERHEAD Power Transmission, The Use of Wooden Poles for, C. Wade, 309
PLANTS, Large Gas Power, C. E. Douglas, 63
Poles for Overhead Power Transmission, The Use of Wooden, C. Wade, 309
Poles, Machine-made, Ferro-Concrete, 365
Power in Copper Production, Electric, 10
Power Plants, Large Gas, C. E. Douglas, 63
Power, Progress in Electric, 7
Power Transmission, The Use of Wooden Poles for Overhead, C. Wade, 309
Production, Electric Power in Copper, 10
Progress in Electric Power, 7

Pumping for Docks, Electric, W. C. Mountain, 253
Pumps for Railway Tank Supply, Automatic Electric, 9
Railway Tank Supply, Automatic Electric Pumps for, 9
Single-Phase Induction Motors, The Starting of, 316
Starting of Single-Phase Induction Motors, The, 316
Supply, Automatic Electric Pumps for Railway Tank, 9
Tank Supply, Automatic Electric Pump for Railway, 9
Tension Transmission, Very High, 9
Transmission, The Use of Wooden Poles for Overhead Power, C. Wade, 309
Transmission, Very High Tension, 9
Use of Wooden Poles for Overhead Power Transmission, The, 309.
Very High Tension Transmission, 9
Wade, C., The Use of Wooden Poles for Overhead Power Transmission, 309
Wooden Poles for Overhead Power Transmission, The Use of, C. Wade, 309

Traction and Transport.

Bergman, B. G., Tractive effort of the Single-Phase Commutator Motor, 73
Brompton Railway, The Great Northern, Piccadilly and, 11
Commutator Motor, Tractive Effort of the Single-Phase, B. G. Bergman, 73
Consumption of Steam and Electric Railways, Fuel, 72
Converters, Motor Generators *versus* Synchronous, P. M. Lincoln, 318
Cost of Electric Mining Locomotives, Operating, 75
Development, Electric Traction, 11
Dumbarton Electric Tramways, The, 258
Effort of the Single-Phase Commutator Motor, Tractive, B. G. Bergman, 73
Electric Locomotive, Rectifier for, 69
Electric Mining Locomotives, Operating Costs of, 75
Electric Railways, Fuel Consumption for Steam and, 72
Electric Traction Development, 11
Electric Tramways, The Dumbarton, 258
Electric Trunk Line Operation, Some Facts and Problems Bearing on, F. J. Sprague, 367.
Facts and Problems Bearing on Electric Trunk-line Operation, Some, F. J. Sprague, 367
Fuel Consumption of Steam and Electric Railways, 72
Great Northern Piccadilly and Brompton Railway, The, 11
Lincoln, P. M., Motor Generators *versus* Synchronous Converters, 318
Locomotives, Operating Costs of Electric Mining, 75
Locomotives, Rectifier for Electric, 69
Locomotive, Tests of Ward-Leonard-Oerlikon, 15
Mining Locomotives, Operating, Costs of Electric, 75
Motor, Tractive Effort of the Single-Phase Commutator, B. G. Bergman, 73
Motor-Generators *versus* Synchronous Converters, P. M. Lincoln, 318
Operating Costs of Electric Mining Locomotives, 75
Piccadilly and Brompton Railway, The Great Northern, 11
Problems bearing on Electric Trunk-line Operation, Some Facts and, F. J. Sprague, 367
Railways, Fuel Consumption of Steam and Electric, 72
Railway, The Great Northern, Piccadilly, and Brompton, 11
Rectifier for Electric Locomotives, 69
Single-Phase Commutator Motor, Tractive Effort of the, B. G. Bergman, 73
Sprague, F. J., Some Facts and Problems Bearing on Electric Trunk-Line Operation, 367
Steam and Electric Railways, Fuel Consumption, 72
Synchronous Converters, Motor-Generators *versus*, P. M. Lincoln, 318
Tests of Ward-Leonard-Oerlikon Locomotives, 15
Traction Development, Electric, 11
Tractive Effort of the Single-Phase Commutator Motor, B. G. Bergman, 73
Tramways, The Dumbarton Electric, 258
Trunk-Line Operation, Some Facts and Problems Bearing on Electric, F. J. Sprague, 367.
Ward-Leonard-Oerlikon Locomotive, 15

Central Station Practice.

Ashe, S. W., Practice *versus* Theory in Substation Operation, 20
Bissell, G. W., Tests of a Producer Gas Engine, 261
Bushnell, O. Meter Testing, 322
Central Station Progress, 19
Central Station Supply Economics, A. M. Taylor, 76, 262
Circuits, Earth Detector for Three-Phase, F. E. Conrad, 371
Conrad, F. E., Earth Detector for Three-Phase Circuits, 371
Detector for Three-Phase Circuits, Earth, F. E. Conrad, 371
Devices, Modern Switchboard, C. W. Stone, 81
Earth Detector for Three-Phase Circuits, F. E. Conrad, 371
Economics, Central Station Supply, A. M. Taylor, 76, 262
Engine, Tests of a Producer Gas, G. W. Bissell, 261
Gas Engine, Tests of a Producer, G. W. Bissell, 261
Meter Testing, O. Bushnell, 322
Modern Switchboard Devices, C. W. Stone, 81
Operation, Practice *versus* Theory in Substation, S. W. Ashe, 20
Practice *versus* Theory in Substation Operation, S. W. Ashe, 20
Producer Gas Engine, Tests of a, G. W. Bissell, 261
Progress, Central Station, 19
Station Progress, Central, 19
Station Supply Economics, Central, A. M. Taylor, 76, 262
Stone, C. W., Modern Switchboard Devices, 81
Substation Operation, Practice *versus* Theory in, S. W. Ashe, 20
Supply Economics, Central Station, A. M. Taylor, 76, 262
Switchboard Devices, Modern, C. W. Stone, 81
Taylor, A. M., Central Station Supply Economics, 76, 262
Testing Meter, O. Bushnell, 322
Tests of a Producer Gas Engine, G. W. Bissell, 261
Theory in Substation Operation, Practice *versus*, S. W. Ashe, 20
Three-Phase Circuits, Earth Detector for, F. E. Conrad, 371

Lighting and Heating.

Annealing by Electric Arc, Saw, L. L. Arnold, 86
Arc, Saw Annealing by Electric, L. L. Arnold, 86
Arnold, L. L., Saw Annealing by Electric Arc, 86
Ayer, J. I., Domestic Electric Heating, 25
Candle-Power Diminution in Frosted Lamps, The Causes, P. S. Millar, 327
Causes of Candle-Power Diminution in Frosted Lamps, The, P. S. Millar, 327
Clark, W. G., and H. C. Parker, The Helion Filament Incandescent Lamp, 83
Comparisons, Incandescent Lamp, 24
Cooking, Electric, 269
Cooper Hewitt Lamps in a Steam Room, 86
Diminution in Frosted Lamps, The Causes of Candle-Power, P. S. Millar, 327
Domestic Electric Heating, J. I. Ayer, 25
Electric Arc, Saw Annealing by, L. L. Arnold, 86
Electric Cooking, 269
Electric Heating, Domestic, J. I. Ayer, 25
Electric Lighting and Heating, Prospects in, 23
Electric Steel Furnaces, Progress in, 331
Filament Incandescent Lamp, The Helion, H. C. Parker and W. G. Clark, 83
Frosted Lamps, The Causes of Candle-Power Diminution in P. S. Millar, 327
Frosted Lamps, The Short Life of, E. P. Hyde, 329
Furnaces, Progress in Electric Steel, 331
Heating, Domestic Electric, J. I. Ayer, 25
Heating, Prospects in Electric Lighting and, 23
Helion Filament Incandescent Lamp, The, H. C. Parker and W. G. Clark, 83
Hewitt Lamps in a Steam Room, Cooper, 86
Hyde, E. P., The Short Life of Frosted Lamps, 329
Incandescent Lamp Comparisons, 24
Incandescent Lamp, The Helion Filament, H. C. Parker and W. G. Clark, 83
Induction, Mercury Vapour Lamps Operated by, 267
Lamp Comparisons, Incandescent, 24
Lamps in a Steam Room, Cooper Hewitt, 86
Lamps, The Causes of Candle-Power Diminution in Frosted, P. S. Millar, 327
Lamps, The Short Life of Frosted, E. P. Hyde, 329
Lamp, The Helion Filament Incandescent, H. C. Parker and W. G. Clark, 83
Life of Frosted Lamps, The Short, E. P. Hyde, 329
Light at the Savoy Hotel, The Moore, 380
Lighting and Heating, Prospects in Electric, 23
Light, The Moore, D. McFarlan Moore, 373
Mercury Vapour Lamps Operated by Induction, 267
Millar, P. S., The Causes of Candle-Power Diminution in Frosted Lamps, 327
Moore, D. McFarlan, The Moore Light, 373
Moore Light at the Savoy Hotel, The, 380
Moore Light, The, D. McFarlan Moore, 373
Parker, H. C. and W. G. Clark, The Helion Filament Incandescent Lamp, 83
Progress in Electric Steel Furnaces, 331
Prospects in Electric Lighting and Heating, 23
Savoy Hotel, The Moore Light at the, 380
Saw Annealing by Electric Arc, L. L. Arnold, 86
Short Life of Frosted Lamps, The, E. P. Hyde, 32
Steam Room, Cooper Hewitt Lamps in a, 86
Steel Furnaces, Progress in Electric, 331
Vapour Lamps Operated by Induction, Mercury, 26

Telegraphy and Telephony.

Care of Platinum Points, L. Casper, 32
Casper, L., Care of Platinum Points, 32
Cohen, B. S. and G. M. Shepherd, Telephonic Transmission Measurements, 336, 381
Electrical Oscillations, Sustained, 88
Kessler, J. J., The Preservation of Poles and Timber, 275
Measurements, Telephonic Transmission, B. S. Cohen and G. M. Shepherd, 336, 381
New System of Telegraphy, A, 87
New Telegraphy, The, 27
Oscillations, Sustained Electrical, 88
Platinum Points, Care of, L. Casper, 32
Points, Care of Platinum, L. Casper, 32
Poles and Timber, The Preservation of, J. J. Kessler, 275
Poles, Strength of Wooden, 89
Preservation of Poles and Timber, The, J. J. Kessler, 275
Relays, Telephone, J. Trowbridge, 29
Shepherd, G. M. and Cohen, Telephonic Transmission Measurements, 336, 381
Simultaneous Telephone and Telegraph, F. M. Slough and M. E. Taylor, 271
Slough, F. M. and M. E. Taylor, Simultaneous Telephone and Telegraph, 271
Strength of Wooden Poles, 89
Submarine Telegraphy, 332
Sustained Electrical Oscillations, 88
System of Telegraphy, A New, 87
Taylor, M. E. and F. M. Slough, Simultaneous Telephone and Telegraph 271
Telegraph, Simultaneous Telephone and, F. M. Slough and M. E. Taylor, 271.
Telegraphy, A New System of, 87.
Telegraphy, Submarine, 332
Telegraphy, The New, 27
Telephone and Telegraph, Simultaneous, F. M. Slough and M. E. Taylor, 271
Telephone Relays, J. Trowbridge, 29
Telephonic Transmission Measurements, B. S. Cohen and G. M. Shepherd, 336, 381
Timber, The Preservation of Poles and, J. J. Kessler, 275
Transmission Measurements, Telephonic, B. S. Cohen and G. M. Shepherd, 336, 381
Trowbridge, J., Telephone Relays, 29
Wooden Poles, Strength of, 89

Electrical Design and Manufacture.

Armature Diameter, Estimation of, L. A. Freudenberger, 90
Behrend, B. A., The Practicability of Large Generators Wound for 20,000 Volts, 337
Diameter, Estimation of Armature, L. A. Freudenberger, 90
Drying-out Plant, Method of, S. L. Sinclair and E. D. Tyree, 92
Estimation of Armature Diameter, L. A. Freudenberger, 90
Freudenberger, L. A., Estimation of Armature Diameter, 90
Generators Wound for 20,000 Volts, The Practicability of Large, B. A. Behrend, 337
Hunt, Louis J., A New Type of Induction Motor, 277
Induction Motor, A New Type of, Louis J. Hunt, 277
Kintner, S. M., The Treating of Transformer Oil, 93
Large Generators Wound for 20,000 Volts, The Practicability of, B. A. Behrend, 337
Method of Drying-out Plant, S. L. Sinclair and E. D. Tyree, 92
Motor, A New Type of Induction, Louis J. Hunt, 277
New Type of Induction Motor, A, Louis J. Hunt, 277
Oil, The Treating of Transformer, S. M. Kintner, 93
Plant, Method of Drying-out, S. L. Sinclair and E. D. Tyree, 92
Practicability of Large Generators Wound for 20,000 Volts, The, B. A. Behrend, 337
Series Transformers, 60,000-Volt, W. H. Thompson, 33
Sinclair, S. L., and E D. Tyree, Method of Drying-out Plant, 92
60,000-Volt Series Transformers, W. H. Thompson, 33
Thompson, W. H., 60,000-Volt Series Transformers, 33
Transformer Oil, The Treating of, S. M. Kintner, 93
Transformers, 60,000-Volt Series, W. H. Thompson, 33
Treating of Transformer Oil, The, S. M. Kintner, 93
20,000 Volts, The Practicability of Large Generators Wound for, B. A. Behrend, 337
Type of Induction Motor, A New, Louis J. Hunt, 277
Tyree, E. D. and S. L. Sinclair, Method of Drying-out Plant, 92

Electro-Chemistry, Electro-Physics, and Electro-Metallurgy.

Alundum—Its Manufacture and Characteristics, 35
Artificial Soft Graphite, 34
Atmospheric Nitrogen, Fixation of, 340
Bleaching Liquors, 287
Caseine, Electrolytic, 392
Cell, The Standard, F. A. Wolff and C. E. Waters,
Celluloid, Notes on, 285
Characteristics, Alundum—Its Manufacture and, 35
Concrete, Electrolysis in Ferro-, 343
Contributions to the Study of Strong Electrolytes, A. C. C. Cumming, 286
Cumming, A. C. C., Contributions to the Study of Strong Electrolytes, 286
Development in the Electrical Manufacture of Steel, 97
Electric Steel, 284
Electrical Manufacture of Steel, Development in the, 97
Electrolysis in Ferro-Concrete, 343
Electrolytes, Contributions to the Study of Strong, A. C C. Cumming, 286
Electrolytic Caseine, 392
Electrolytic Extraction of Gold, 34
Extraction of Gold, Electrolytic, 34
Ferro-Concrete, Electrolysis in, 343
Fixation of Atmospheric Nitrogen, 340
Furnaces; The "Pinch" Phenomenon, A Practical Limitation of Resistance, 389
Gold, Electrolytic Extraction of, 34
Graphite, Artificial Soft, 34
Limitation of Resistance Furnaces; The "Pinch" Phenomenon, A Practical, 389
Liquors, Bleaching, 287
Manufacture and Characteristics, Alundum—Its, 35
Manufacture of Steel, Development in the Electrical, 97
Nitrogen, Fixation of Atmospheric, 340
Notes on Celluloid, 285
Phenomenon, A Practical Limitation of Resistance Furnaces; The "Pinch," 389
"Pinch" Phenomenon, A Practical Limitation of Resistance Furnaces; The, 389
Practical Limitation of Resistance Furnaces; The "Pinch" Phenomenon, A, 389
Resistance Furnaces; The "Pinch" Phenomenon, A Practical Limitation of, 389
Soft Graphite, Artificial, 34
Standard Cell, The, F. A. Wolff and C. E. Waters, 95
Steel, Development in the Electrical Manufacture of, 97
Steel, Electric, 284
Strong Electrolytes, Contributions to the Study of, A. C. C. Cumming, 286
Waters, C. E. and F. A. Wolff, The Standard Cell, 95
Wolff, F. A. and C. E. Waters, The Standard Cell, 95

Students' Section.

Brake, A Self-Regulating, H. M. Scheibe, 288
Cable Insulation, Measurement of Wire and, F. Wachter, 289
Canada as a Field for the Electrical Engineer, C. F. Gray, 98
Course of the Westinghouse Electric and Manufacturing Company, U.S.A., Engineering, H. D. Shute, 393
Dynamos in Parallel, 99
Electric Furnaces, Laboratory, 395
Electrical Engineer, Canada as a Field for the, C. F. Gray 98
Engineering Course of the Westinghouse Electric and Manufacturing Company, U.S.A., H. D. Shute, 393
Field for the Electrical Engineer, Canada as a, C. F. Gray, 98
Furnaces, Laboratory Electric, 395
Gray, C. F., Canada as a Field for the Electrical Engineer, 98
Growing Opportunity, A, 37
Insulation, Measurement of Wire and Cable, F. Wachter, 289
Jackson, R. P., A Peculiar Static Trouble, 38
Laboratory Electric Furnaces, 395
Manufacture of Rubber-Insulated Wire, The, H. T. Wreaks, 344
Measurement of Wire and Cable Insulation, F. Wachter, 289
Measurement, Three-Phase Power, H. M. Scheibe, 99
Opportunity, A Growing, 37
Parallel, Dynamos in, 99
Peculiar Static Trouble, A, R. P. Jackson, 38
Power Measurement, Three-Phase, H. M. Scheibe, 99
Rubber-Insulated Wire, The Manufacture of, H. T. Wreaks 344
Scheibe, H. M., A Self-Regulating Brake, 288
Scheibe, H. M., Three-Phase Power Measurement 99
Self-Regulating Brake, A, H. M. Scheibe, 288
Shute, H. D., Engineering Course of the Westinghouse Electric and Manufacturing Company, U.S.A 393
Skilled Workmen, The Training of, 290
Static Trouble, A Peculiar, R. P. Jackson, 38

205714

Three-Phase Power Measurement, H. M. Scheibe, 99
Training of Skilled Workmen, The, 290
Trouble, A Peculiar Static, R. P. Jackson, 38
Wachter, F., Measurement of Wire and Cable Insulation, 289
Westinghouse Electric and Manufacturing Company, U.S.A., Engineering Course of the, H. D. Shute, 393
Wire and Cable Insulation, Measurement of, F. Wachter, 289
Wire, The Manufacture of Rubber-Insulated, H. T. Wreaks, 344
Workmen, The Training of Skilled, 290
Wreaks, H. T., The Manufacture of Rubber-Insulated Wire 344

Wiremen's Section.

Breakdowns of Electrical Machinery, L. Foster, 346
Buildings, Conduit Work in Fireproof, T. W. Poppe, 293
Buildings, Wiring Work in Completed Fireproof, T. W. Poppe, 101
Conduit Work in Fireproof Buildings, T. W. Poppe, 293
Direct-Current Machines and their Remedies, Some Troubles of, W. H. Eager, 397
Dusty Places, Protection of Motors in, K. Williams, 395
Eager, W. H., Some Troubles of Direct-Current Machines and Their Remedies, 397
Electrical Machinery, Breakdowns of, L. Foster, 346
Fireproof Buildings, Conduit Work in, T. W. Poppe, 293
Fireproof Buildings, Wiring Work in Completed, T. W. Poppe, 101
Foster, L., Breakdowns of Electrical Machinery, 346
Machinery, Breakdowns of Electrical, L. Foster, 346
Machines and their Remedies, Some Troubles of Direct Current, W. H. Eager, 397
Motors in Dusty Places, Protection of, K. Williams, 396
Poppe, T. W., Conduit Work in Fireproof Buildings, 293
Poppe, T. W., Wiring Work in Completed Fireproof Buildings, 101
Protection of Motors in Dusty Places, K. Williams, 396
Remedies, Some Troubles of Direct-Current Machines and Their, W. H. Eager, 397
Troubles of Direct-Current Machines and their Remedies, Some, W. H. Eager, 397
Williams, K, Protection of Motors in Dusty Places, 396
Wiring Work in Completed Fireproof Buildings, T. W Poppe, 101

Manufacturing Progress.

Ammeters for General Power Use, Dead-beat, 295
Arc Lamp, "Santoni" Flame, 50
Arc Lamps, 56
Arc Lamps for Railways, 53
Arc Lamps, "Kohinoor," 296
Blocks, Electric Transporters and Pulley, 356
Cable Drum Carriage, The Triumph, 357
Cable Tests, Some Remarkable, 414
Carriage, The Triumph Cable Drum, 357
Colliery Plant, 299
Controller, A Large Lift, 108
Conduit Enamels, Wiring, 298
Damper Regulator, A Large Three-Phase, 108
Dead-beat Ammeters for General Power Use, 295
Demand Indicators, 56
Device, "Time Lag" Safety, 106
Drum Carriage, The Triumph Cable, 357
Electric Transporters and Pulley Blocks, 356
Enamels, Wiring Conduit, 298
Engineering and Machinery Exhibition, London, 1907, The, 105
Engineering Export Trade, 103
Exhibition, London, 1907, The Engineering and Machinery, 105
Export Trade, Engineering, 103
Facts, 1906-1907, Manufacturers', 40
Ferranti Steam Valve, Hopkinson- 54
Fitting, A Novel Table, 416
Fittings, Up-to-date, 355
Flame Arc Lamp, "Santoni," 50
Gas Producers, 51
Hopkinson-Ferranti Steam Valve, 54
Indicators, Demand, 56
Indicators, "Perfect" Speed, 412
Insulating Varnish, The Use of, 296
J. and P. Patent Time Switch, The, 416
J. and P. Prepayment Meter, The, 415
"Kohinoor" Arc Lamps, 296
Lamp, "Santoni" Flame Arc, 50
Lamps, Arc, 56
Lamps for Railways, Arc, 53
Lamps, "Kohinoor" Arc, 296
Lift Controller, A Large, 108
Machinery Exhibition, London, 1907, The Engineering and, 105
Manufacturers' Facts, 1906-1907, 40
Meter, The J. and P. Prepayment, 415
Meters, Supply, 56
Motor-car Specialities, 109
Novel Table Fitting, A, 416
"Perfect" Speed Indicators, 412
Plant, Colliery, 299
Prepayment Meter, The J. and P., 415
Producers, Gas, 51
Progress, The Van of, 410
Pulley Blocks, Electric Transporters and, 356
Railways, Arc Lamps for, 53
Regulator, A Large Three-Phase Damper, 108
Remarkable Cable Tests, Some, 414
Safety Device, "Time Lag," 106
"Santoni" Flame Arc Lamp, 50
Specialities, Motor-car, 109
Speed Indicators, "Perfect," 412
Steam Valve, Hopkinson-Ferranti, 54
Supply Meters, 56
Switch, The J. and P. Patent Time, 416
Table Fitting, A Novel, 416
Taximeter, The, 413
Tests, Some Remarkable Cable, 414
Three-Phase Damper Regulator, A Large, 108
"Time Lag" Safety Device, 106
Time Switch, The J. and P. Patent, 416
Trade, Engineering Export, 103
Transporters and Pulley Blocks, 356
Triumph Cable Drum Carriage, The, 357
Up-to-Date Fittings, 355
Use of Insulating Varnish, The, 296
Valve, Hopkinson-Ferranti Steam, 54
Van of Progress, The, 410
Varnish, The Use of Insulating, 296
Wiring Conduit Enamels, 298

Electric Power in Collieries.

Some General Points, 121
The Electric Power Supply, 122
Gas or Steam Units, 122
Gas Power Plant, 123
Steam Power Plant, 125
Fuel Economy, 126
Steam Economies, 129
Water Treatment, 132
Alternate Current or Direct Current, 132
Electric Generating Plant, 134
Main Switchboards, 136
Current Transmission and Distribution, 138
Selection of Cables, 138
Armoured Flexible Cables, 139
Wiring Work, 141
Underground Switch-gear, 144
Leakage Indicators (A. F. Harris, A.M.I.E.E.), 150
Electrical Winding, 155
Some New Flywheel Storage Systems (A. P. Wood), 156
Winding Economy and First Cost, 169
Electrical Haulage, 170
Electric Locomotives, 179
Electric Pumping, 184
Electric Coal-cutters, 196
Electric Coal Drills, 215
Auxiliary Electric Power Appliances and Accessories, 221
Some Typical Colliery Installations, 227
The Aberdare Collieries of the Powell Duffryn Co. (Charles P. Sparks), 227
The Electric Power Equipment of the Tarbrax Oil Co., Ltd. (James Caldwell), 239
Electric Power Installation at Bradford Colliery, 240
The Mountain Ash Collieries of Nixon's Navigation Colliery Co., 246
Bwilfa Collieries, 248

Medical Electricity.

Dr. Schnee's Four-Cell Bath, A. Roberts, M.D., 351
Recent Developments in Radiography, G. Pearce 399
The Radiant Heat and Light System of Medical Treatment, H. J. Dowsing, 404
Practice with X-Ray Work, C. W. J. Morley, 408
New Catalogues, 58D, 114, 417
Trade Notices and Personal, 58, 110, 417
Reviews of Books, 58A, 111, 302, 359
The World's Electrical Literature, 58C, 116, 304, 418
Practical Books, 58C, 248A

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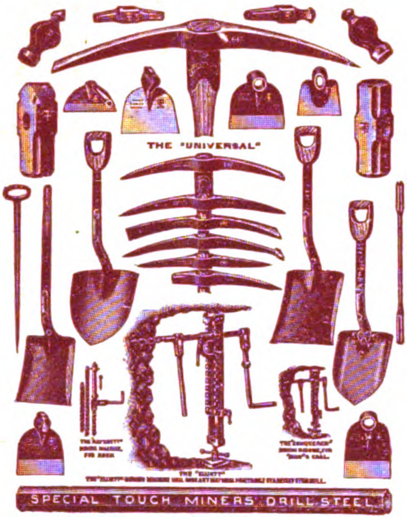
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Turn to LITERARY SECTION, p. 58a, and particularly note p. 58e

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Buyers' Guide—*continued.*

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……

Index to Advertisers.

For specialities and manufactures of firms below, see preceding Buyers' Guide.

	PAGE
A. E. G. Electrical Co. of South Africa, Ltd.	7
A. E. G. English Manufacturing Co., Ltd.	13
Adams Manufacturing Co., Ltd.	
Angus, George, & Co., Ltd.	
Armorduct Manufacturing Co., Ltd.	
Automatic Standard Screw Co.	ii. of cover
Babcock & Wilcox, Ltd.	6
Bateman's Machine Tool Co., Ltd	
Bayliss, Jones & Bayliss, Ltd.	
Bennis, Ed., & Co., Ltd.	29
British Electric Plant Co., Ltd.	
British Steam Specialties, Ltd.	28
British Westinghouse Electric & Mfg. Co., Ltd.	15
Broadbent, Thos., & Sons, Ltd.	
Campbell Gas Engine Co., Ltd.	22 and 23
Clarke, Chapman & Co., Ltd.	4
Connolly Brothers, Ltd.	25
Craven Bros., Ltd.	
Crompton & Co., Ltd.	5
Crypto Electrical Co.	
Cundall, Sons & Co., Ltd.	
"Cyclopædia of Applied Electricity"	vii of Supp.
Diesel Engine Co., Ltd.	10
Edwards Air Pump Syndicate, Ltd.	
Electric & Ordnance Accessories Co., Ltd.	18
Electrical Standardizing, Testing & Training Institution	iii. of cover
Electromotors, Ltd.	
Ferranti, Ltd.	21
General Electric Co., Ltd.	18
Glaholm & Robson, Ltd.	
Green, E., & Son, Ltd.	16
Halden, J., & Co.	29
Hall, B. J., & Co., Ltd.	
Hardy Patent Pick Co., Ltd.	ii of cover
Hendry, James	iii of cover
High Speed Braiding Machine Co., Ltd.	28
Holmes, J. H., & Co.	17
Holroyd, John, & Co., Ltd.	
Hornsby, Richard & Sons, Ltd.	9
Hulse & Co., Ltd.	
Hyatt Roller Bearing Co.	

should consult the Special Literary Section of The ELECTRICAL MAGAZINE

Index to Advertisers—*continued.*

PAGE
India-Rubber, Gutta-Percha, & Tel. Wks. Co., Ltd. 11
Industrial Engineering and Motor Co., Ltd. . 3
Kuettner, Macdonell & Cookson, Ltd. . .
Lancaster & Tonge, Ltd. . . . . . .
London & County Printing Works 31
Longmans, Green & Co. 58f
Macintyre, James, & Co., Ltd. . . . . .
McGeoch, Wm. & Co., Ltd. 17
Meldrum Bros, Ltd. 6
"Modern Electric Practice" . . . . .
"Modern Engines and Power Generators" . .
Morris-Hawkins Electrical Co., Ltd. . . . 21
Mountain & Gibson, Ltd. 12
Nalder Bros. & Thompson, Ltd. . . . 8 and 26
Newton Bros. 28
North-Western Electrical Appliance Co. . . 17
Pearn, Frank, & Co., Ltd. 26
Phillips, Charles D. 26
Phœnix Dynamo Manufacturing Co., Ltd. . . 20
Press Etching Co. 30
Pritchetts & Gold, Ltd. . . . . . .
Reason Manufacturing Co., Ltd. . . . 2
Rhodes Electrical Manufacturing Co., Ltd.. .
Rockwell-Wabash Co., Ltd. . . . . .

PAGE
Ross, R. G., & Son . . . . iii. of cover
Santoni, D., & Co. (1906), Ltd.
Selig, Sonnenthal & Co. . . . . .
Simplex Conduits, Ltd. 32
Smith (A.) and Stevens. 27
Sprowson, William, & Co. . . . . .
"Standard Wiring" . . . .
Stirk, John, & Sons . . . .
Stolzenberg Patent File Co. . . . . .
Sun Electrical Co., Ltd. 32
Suter, Frank, & Co., Ltd. . . . . 14 and Supp. v
Temperley Transporter Co. 8
Thames Ironworks, Shipbuilding and Engineering Co., Ltd. . . . . .
Thom, John G. . . . . iv. of cover
Trading and Manufacturing Co., Ltd. . .
Turnbull, Alex., & Co., Ltd. 16
Union Electric Co., Ltd. 19
United States Metallic Packing Co., Ltd. . . 24
Waygood, R., & Co., Ltd. . . . . .
White, J. G., & Co., Ltd. . . . . .
Wild, M. B., & Co., Ltd. 24
Winn, Charles, & Co.. . . . . . .
"The World of To-day" . . . . . .
"World's Work" . . . . . . Supp. vi

LITERARY CONTENTS of this Issue of

The ELECTRICAL MAGAZINE.

PAGES
The World's Electric Progress . . . 1-6
Retrospect and Prospect, 1906-1907 . . . 1-2
Enterprise in Journalism 2-3
Popularizing Electricity in the U.S.A.—The Co-operative Electrical Development Association 3-5
The Industrial Power Problem . . . 5-6
The Channel Tunnel 6
Power 7-10
Progress in Electric Power 7-9
Automatic Electric Pumps for Railway Tank Supply 9
Very High Tension Transmission . . . 9-10
Electric Power in Copper Production . . 10
Traction and Transport 11-18
Electric Traction Development (The Great Northern, Piccadilly and Brompton Railway) 11-15
Tests of Ward-Leonard-Oerlikon Locomotive 15-18
Central Station Practice . . . 19-22
Central Station Progress 19-20
Practice *versus* Theory in Substation Operation. S. W. Ashe 20-22
Lighting and Heating 23-26
Prospects in Electric Lighting and Heating . 23
Incandescent Lamp Comparisons . . . 24
Domestic Electric Heating. J. I. Ayer . . 25-26

PAGES
Telegraphy and Telephony . 27-32
The New Telegraphy 27-28
Telephone Relays. J. Trowbridge . . 29-32
Care of Platinum Points. L. Casper . . 32
Electrical Design and Manufacture . . 33
High-Tension Series Transformers . . 33
Electro-Chemistry, Electro-Physics, and Electro-Metallurgy 34-36
Electrolytic Extraction of Gold . . . 34
Artificial Soft Graphite 34-35
The Manufacture and Properties of Alundum 35-36
Students' Section 37-39
A Growing Opportunity 37-38
A Peculiar Static Trouble . . 38-39
Manufacturing Progress . . 40-58
Manufacturers' Facts, 1906-1907 . . . 40-50
"Santoni" Flame Arc Lamp 50-51
Gas Producers 51-53
Arc Lamps for Railways 53
Hopkinson-Ferranti Steam Valve . . . 54-56
Supply Meters, Demand Indicators, Arc Lamps, &c. 56-58
Trade Notices 58
Literary Section 58a-58f
Reviews of Books 58a-58b
The World's Electrical Literature . . . 58c
New Catalogues 58d
Practical Books 58e-58f

You will find the List of Technical Books (with particulars and prices) **given in the Literary Section invaluable to you.**

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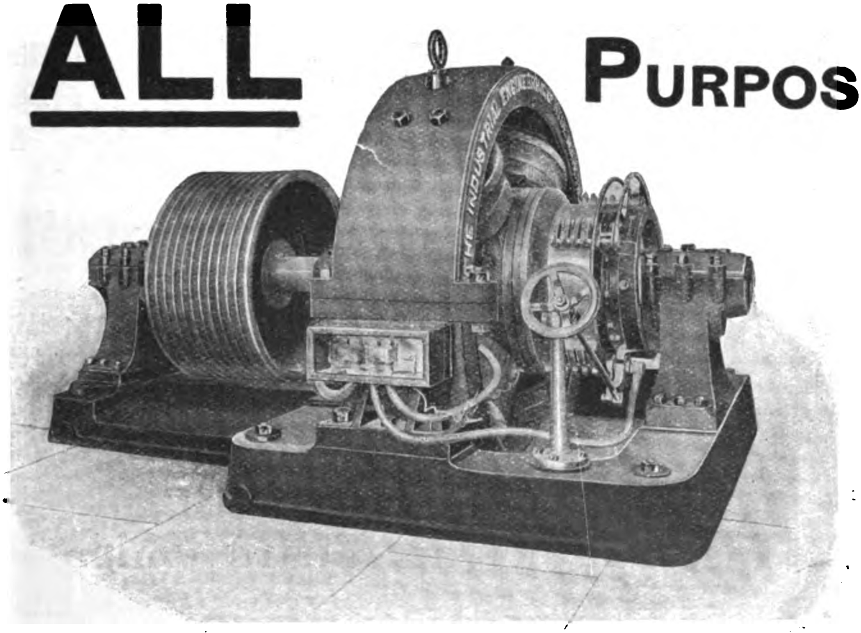

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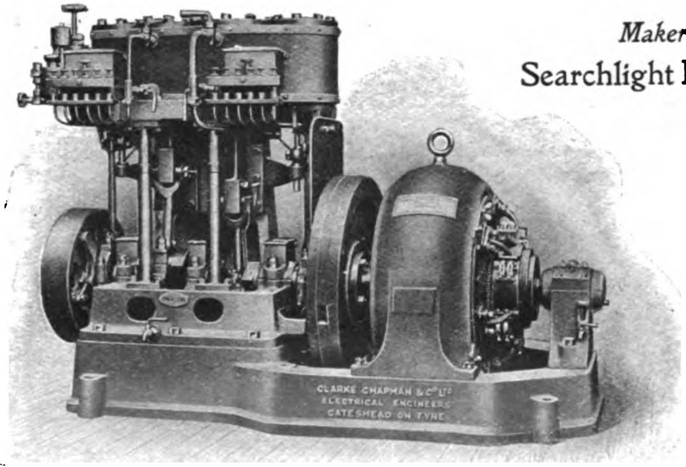

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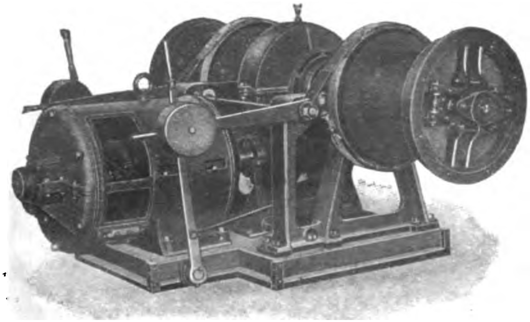

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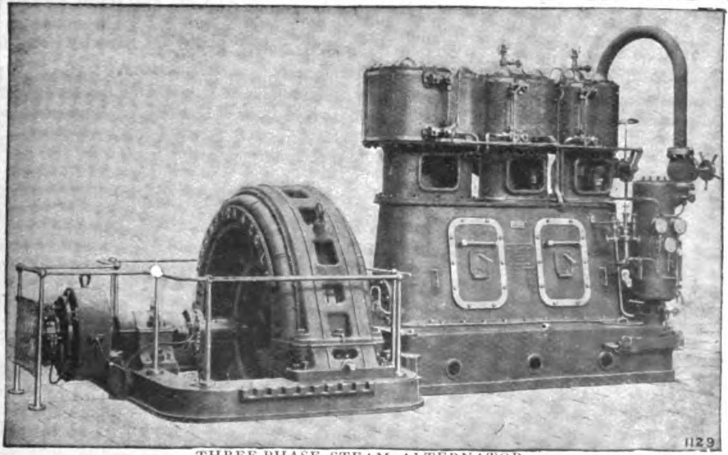

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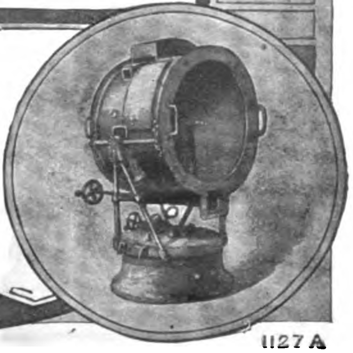

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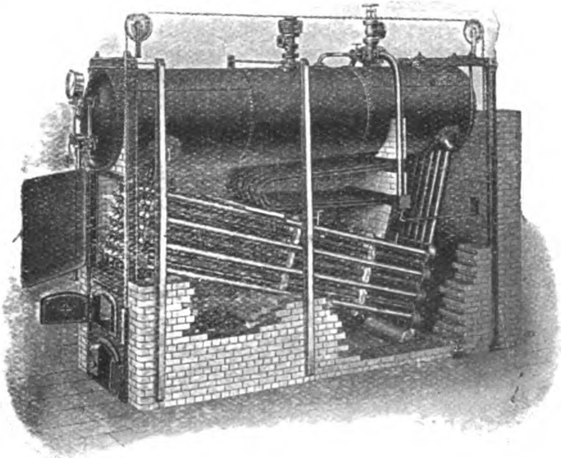

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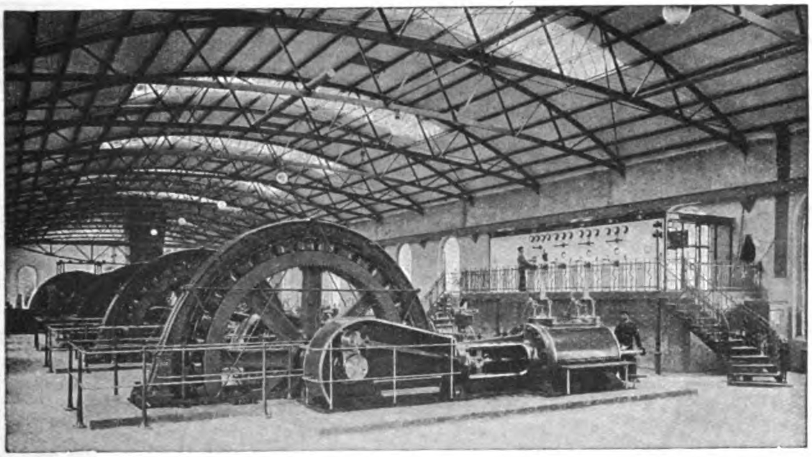

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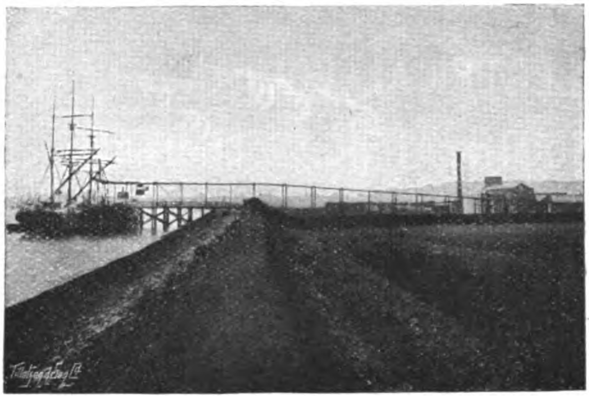

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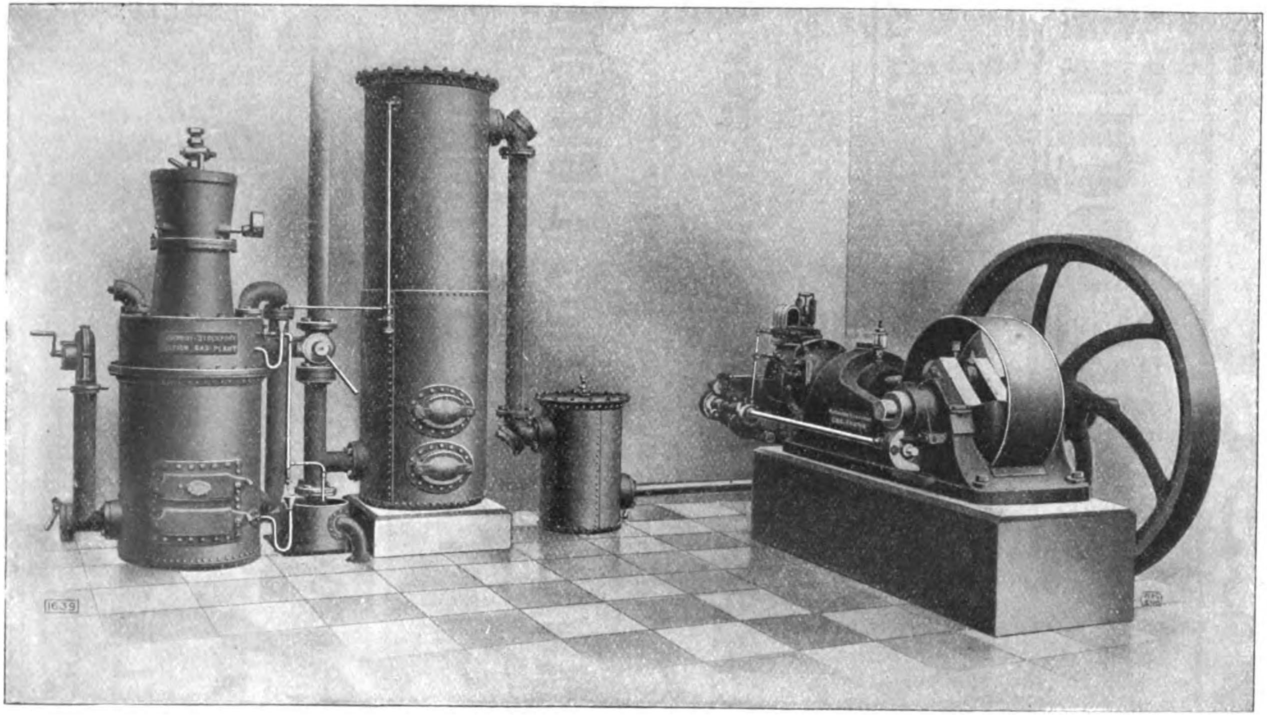

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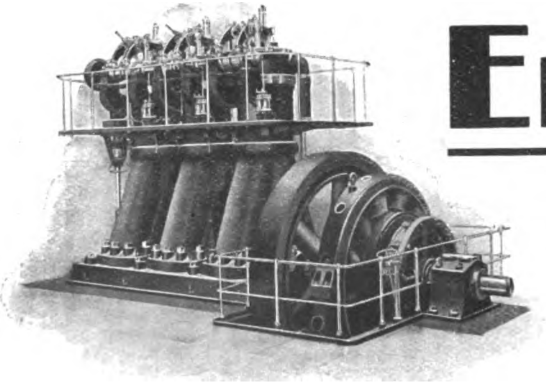

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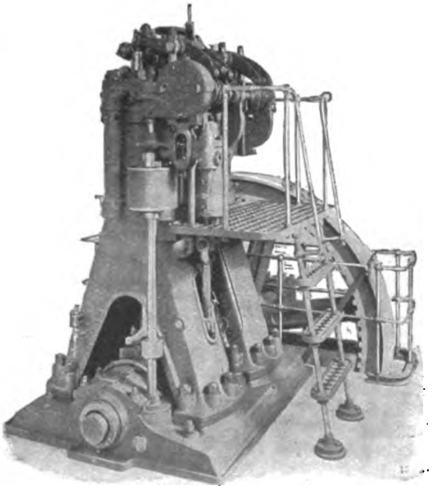

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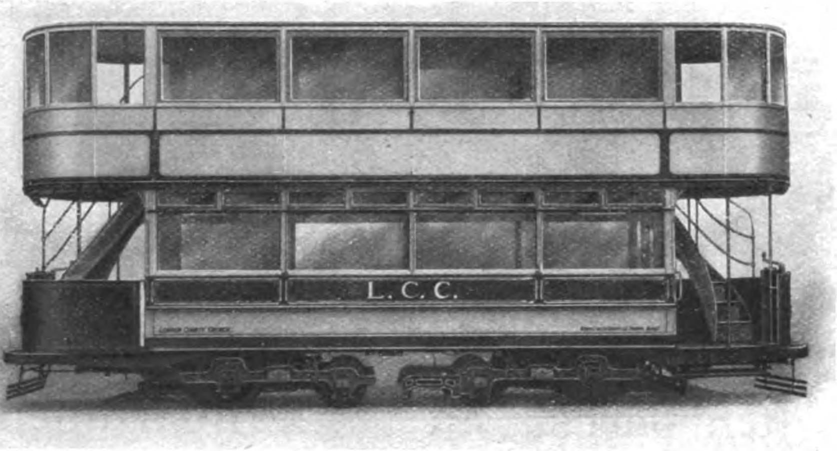

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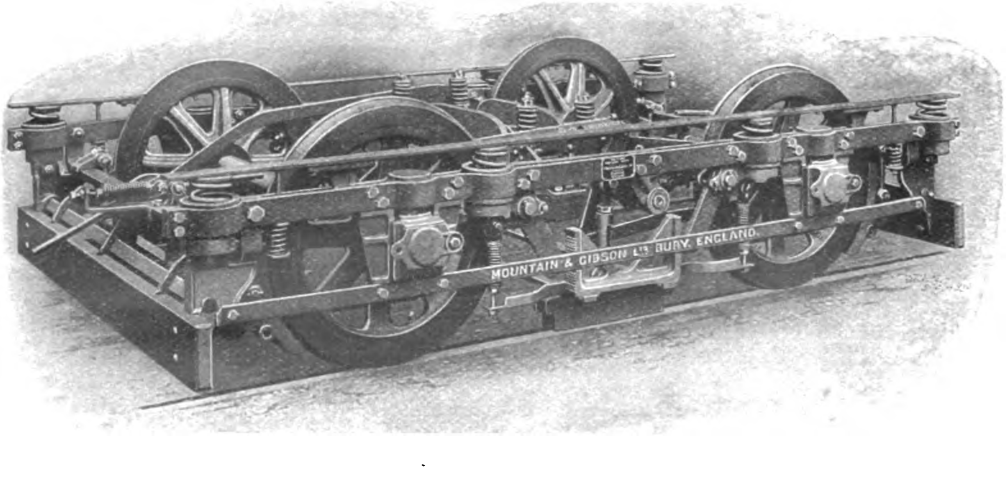

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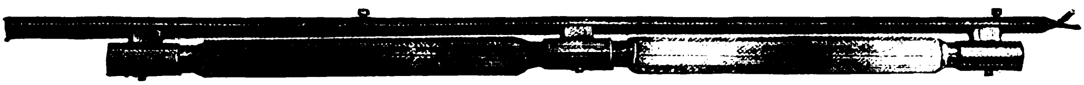

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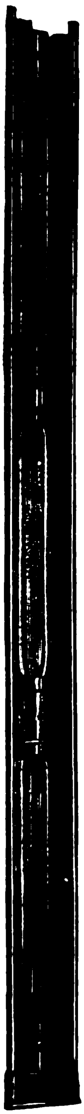

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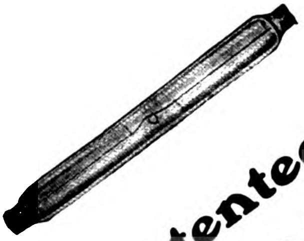

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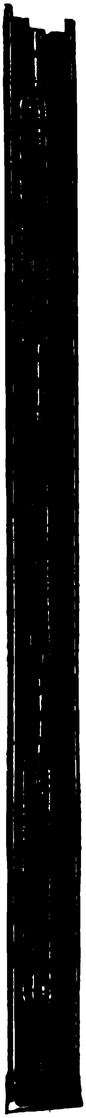

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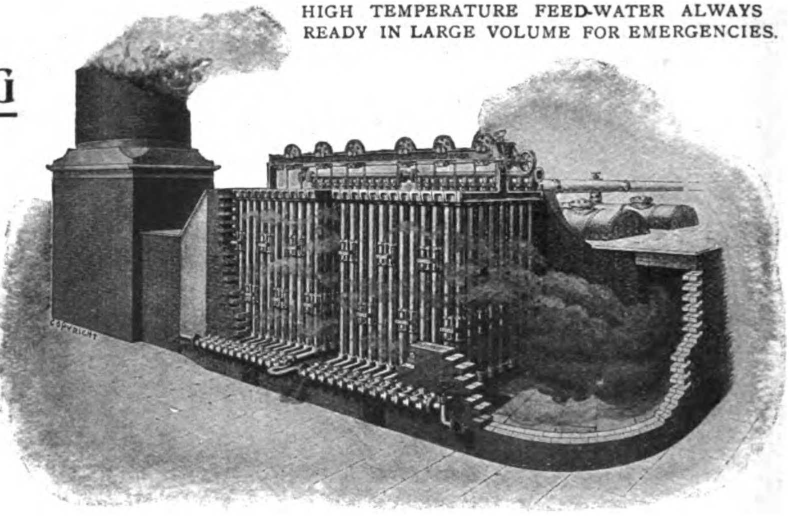

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FOUNDED AND EDITED BY

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VOL. VII. No. 1. (37th Issue.) LONDON. JANUARY, 1907.

The World's Electric Progress.

Retrospect and Prospect, 1906-1907.

THE past year is considered to have been an exceptionally good one; our trade has been greater than ever before; the country has been free from serious internal troubles, and international peace has prevailed. Electricity is so closely allied with every branch of manufacture that the electrical industries have naturally advanced with the common march of progress. It is, however, a fact that the electrical manufacturer is amongst the last to feel the real benefit of an all-round improvement in business—a feature which augurs well for the electrical industry in the New Year.

Speaking generally of industrial conditions as viewed in retrospect and prospect, it would seem that there are wonderful changes afoot in the whole manufacturing industry of this country; changes which will influence the electrical as well as all other trades. It is not in our sphere to discuss, for and against, any political programme—but who can deny that the forces which dictate politics do not equally and at the same time influence commerce and industry? There has been a gradual change in the social state of this country, and the past year has certainly been characteristic of the effects of this change; the power of labour has asserted itself as a leading factor in the constitution and control of the Empire Our trade has been exceptionally great in the past year, so far as the volume of business done is concerned; wages are generally higher than ever; raw materials are quoted at figures far above any that have obtained for many a year past; selling prices of finished products do not show any very marked, and certainly not proportionate, advance. It is not difficult to secure all the orders wished for, at a price; it is quite another matter to secure a large amount of paying business. In this trade boom the worker is getting his price—he has become sufficiently powerful to insure that; but has the master profited any? In the electrical and general engineering industry as time brings out the companies' reports we shall learn. It would seem, therefore, that the New Year dawns under a doubtful condition of things; we welcome it as being of great promise; our workshops are full; wages are high and increasing; we are at peace with the world —all this on the surface. A slight excursion into the depths reveals the possible instability of the position.

In engineering matters we are still very far behind in the cultivation of foreign markets for our products. Practically no progress is being made in this direction, which it would seem should be easiest and also essential for the largest colonising nation of the earth. Our Colonies' complaint of this neglect is still with us; here is an extract from a Canadian contemporary which appeared towards the close of 1906, which is illustrative of our many wasted opportunities:—

> During the past few years, when the United States manufacturer has established some dozens of branch manufacturing plants in Canada, the British industrial community has been an apparently uninterested spectator. Whether caring not or knowing not matters little, as the cold hard fact stares them in the face that an opportunity has been missed that should have been grasped. They may make a move now to overcome an obvious mistake, but this lethargy cannot be overtaken nor the past recalled.

The fact that the announcement recently of a large Coventry firm's intention to establish branch works in this country came as a surprise to the manufacturing public here shows that the unexpected has happened. Whether it indicates a general appreciation of the possibilities in Canada on the part of British manufacturers, or is but an isolated case, is not known. It is, however, a recognition on the part of one wideawake concern, whose enterprise enables it to reach out across the ocean, that this country offers a field for manufacture.

The advertising we have received lately from various sources must some day start the ball rolling. When a general awakening has taken place, which must come, we predict a wholesale scurrying for sites and locations. In the meantime they seem satisfied to wait, and while waiting British manufacturers are making the same mistake as during the past five years in not looking ahead a little, and exploiting the breadth and scope for various manufacturing industries throughout the Dominion.

Then, again, there are the most recent examples of concessions to America for Russian tramways; German capital and plant to supply our new South African colonies with an electrical supply system, which it is intended shall be the largest and most advanced in the world, and so on.

This is to be the year of the Colonial Conference at which the all-important question of the inter-commerce between the several countries of our Empire will be resolved. There has been a marked disposition of late to forget or ignore the ties which bind old England to the Britain beyond the seas. At the Conference, matters will be decided upon which will depend ultimately the cementing of the foundations of the British Empire or their collapse. Either we must give our Colonies preference and so enlist their commercial support for all time, or we must yield them up to the merchants and markets of the foreigner to our own immediate trade loss and the ultimate entire separation of these young and undeveloped nations of our kith and kin from the mother country.

Of trade generally there is the palpable fact that in the guise of economies we are curtailing the real guardians of our commerce. Perhaps the accomplished and intended reductions in the strength of our Navy and Army will not be carried to the extreme of insufficiency—that remains to be proved—but such national policy breeds an uneasiness in the commercial man and certainly tends to destroy any thought he may have of building up a foreign trade. Reduction in our national fighting strength prevents trade expansion. Yet the foreign trade of the year 1906 surpassed all records. The aggregate total of imports and exports exceeded £1,000,000,000. The cause of this prosperity, which is common throughout the world, has nothing to do with the general policy of this country; we have done big business in spite of that policy. Whether we shall eventually profit is another thing altogether, and the thoughtful man will perceive that the too rapid prosperity may end in the greater disaster.

The year 1907 has started well; it rests with ourselves to see that progress is maintained: there must be no fool's paradise, the country is bound sooner rather than later to have commercial questions at issue upon which the integrity of Empire depends, and when these arise let us remember what is often hidden by the glare of prosperity, and so prevent disaster.

In electrical progress the year 1906 has seen much, and many noteworthy accomplishments and discoveries are to be included in its records. The more important of these are dealt with in their respective sections in this number. As to the prospects of the New Year, there are at least two distinct promises of revolution in electrical practice: in telegraphy and telephony, the wireless discoveries of Poulsen are to be the cause; in electric lighting the lately evolved types of metallic filament lamps are to oust our old friend of the carbon filament and become the standard electrical illuminant.

❧

Enterprise in Journalism.

WITH this number THE ELECTRICAL MAGAZINE celebrates its third birthday and enters its fourth year. There have been several recent changes in, and additions to, the ranks of our electrical contemporaries, but this journal is still the standard electrical monthly and is ever increasing in favour as the efficient review of the world's electrical progress, presenting month by month at a small price a survey of electrical work in all its phases.

For the year 1907 we have on hand among other developments the preparation of a series of special numbers which will be of vital importance to all manufacturers, engineers, and traders generally. The respective numbers will be devoted each to a specific branch of applied electricity. To secure this invaluable series, annual subscriptions should be booked now at the commencement of a new volume.

Popularising Electricity in the U.S.A. The Co-operative Electrical Development Association.

BARELY two years ago incandescent electric lamp manufacturers in the United States arrived at the conclusion that their business could be very largely increased if the demand by the general public for electric lighting could be actively stimulated and encouraged It was obvious that this could be done to a certain extent very effectively by any company that cared to meet the necessarily large expenditure that would be involved. However, should any one company carry into effect a scheme with such an object, while benefiting themselves they would at the same time also benefit their competitors, which of course would be a very undesirable result. The potentialities of the idea of popularizing electric lighting were such as to promise highly satisfactory returns, so, wisely, instead of letting the matter drop on account of any inherent impracticability when considered in relation to individual companies, the lamp manufacturers met together and decided to co-operate in a general scheme from which all interested in popularizing the use of incandescent electric lamps would benefit. In May 1905 a special committee was appointed under the chairmanship of Mr. J. Robert Crouse, and the sum of £2000 was placed at the disposal of this committee to cover the preliminary expenses.

In the course of the development of their plans it became evident to the committee that it would be both profitable and advantageous to co-operate with those other branches of the electrical industry which would also benefit very largely if an increased and more extended use of electric current for light, heat, and power could be induced, as it would mean an increased demand for all forms of electrical apparatus and supplies. As a result of this the "Co-operative Electrical Development Association" was formed. In the membership of this Association will be comprised all those companies and individuals who are directly interested in the extension and expansion of electrical interests. At present the actual membership of the Association is chiefly composed of the manufacturers, as would naturally be anticipated, as they are the source of the means of electrical service, and are, owing to their financial position and the conditions under which manufacturing is carried out, the logical interests to initiate the movement. As their example of co-operation comes before the distributing and purchasing trade, it may be expected that in the near future every well-defined interest in the industry will eventually bear its share in the financial arrangements in reasonable proportion to the benefits derived.

A sum of £6000 was expended last year in connection with the preliminary work of this Association, and further plans have been brought up during the past autumn contemplating the expenditure of over £20,000 during the year 1907.

The sums referred to in the last paragraph are large amounts, and consequently the very fact of their being subscribed indicates more eloquently than words what American electrical manufacturers think of the returns they are obtaining already, and hope to get in the near future. The results attained thus far have established the soundness of the general principles of the plans, and the decision to extend them shows that the growth of the electrical business can, by this means, be continuously developed and increased.

Having described the circumstances which led to the formation of this new Association, it will be interesting now to consider the methods whereby the results are being obtained.

The present financial basis of the Association is an appropriation or contribution made by the electrical manufacturers of one-tenth of one per cent. on their sales.

What may, perhaps, be described as the present main practical effort of the Association is carried out through the medium of the central electric supply stations, within whose distribution area is comprised nearly one-half the population of the country. The main argument for commencing with the central station is based on the fact that it is in the peculiar position of being monopolistic in its nature, and subject, therefore, to no competition for like service; in consequence, laying aside any other adverse conditions, it lacks the tonic of a keen and constant commercial stimulus in a field where there are great opportunities if only sufficient energy is put forth to take advantage of them. Also, in spite of the fact that the central station is in a position which naturally might be considered an excellent one for co-operation with other stations, as they are non-competitive, there is no thoroughly aggressive movement in this direction, which would seemingly promise very great results if only properly taken up. Thus it will be seen that a great deal can be effected by the manufacturers and others in initiating co-operative work with and for central stations.

The first step in arousing the interest of the central stations was taken by endeavouring to induce them to deal more fully with the problem of business extension along modern commercial lines. This was done by arranging for the issue of a series of publications at fortnightly intervals dealing with the successful methods, good service, canvassing, and advertising that have been adopted in practice, and reasons for their adoption by all classes of central stations. This commercial literature comprised :—

(*a*) A 32-page quarterly magazine containing notes and articles on all kinds of business-getting schemes, suggestions, and methods.

(*b*) An eight page quarterly newspaper bulletin dealing with central station newspaper advertising, giving samples of good and faulty advertisements, suggestions for advertisements and "write-ups" for the local Press.

(*c*) Specimens of actual commercial literature suitable for use by central stations in an advertising campaign, presenting the effective policies and methods pursued in places where notably good results have been obtained.

The Association also arranges that papers on new business-getting methods should be presented at the meetings of societies and institutions connected with central station interests.

During the course of last year some very valuable prizes were offered for the best papers on the organization of new business departments for central stations in cities of under 50,000 inhabitants. This competition was open to all those who were connected with central station commercial departments or had the management of central stations. The first prize amounted to £100, a sum that made the competition very attractive and aroused considerable attention. The papers of the prize-winners were printed, and a copy sent to every central station. The Association has now announced a prize list for 1907, which totals up to £520. The competition for which these prizes are to be awarded is for three Canvasser's Handbooks, one for Lighting Canvassers, one for Power Canvassers, and the other for Heat Canvassers. The first, second, and third prizes for each of the first two handbooks is £100, £60, and £40 respectively; for the Heat Canvasser's Handbook the prizes are £60, £40, and £20. Not only will a very valuable treatise be got together in this way, covering all the points of good practice and novel selling schemes employed by the most highly trained and successful canvassing forces in the field, but also the very magnitude of the prizes will cause many central station managers, even if they do not enter for the competition, to think seriously and carefully over the means of assistance their canvassers have at their disposal to aid them in their work, and when the handbook is published to take every advantage of it.

The co-operation of the electrical Press has been obtained, with the result that special sections are now regularly devoted to useful notes concerning the extension of the electrical supply industry in accordance with modern commercial practice.

Active steps are also being taken to arouse interest and to obtain the moral co-operation of all individuals identified with the electrical industry as manufacturers, contractors, dealers, &c., as well as the officers of electrical associations and societies of all sorts.

A National Electrical Press Bureau is in the course of formation, somewhat on the basis of the general newsagencies, through which the daily newspapers would be supplied with authentic news and information concerning electrical matters, and also articles of general interest descriptive of things electrical, designed to make electricity a familiar topic, and to displace the foundationless fears associated with what is too often considered to be a mysterious force still in its infancy.

Mr. J. R Crouse, who is the moving spirit of the Association, and who has done so much to put it in the successful position it has now attained, is strongly of the opinion that the general principle of commercial co-operation and generic selling is essentially correct, and will be a matter of common practice and no particular comment in the near future. He further points out that the order of business development may be briefly summed up as follows: Individualism; co-partnership; corporation; consolidation; association; limited co-operation of an industry. That is to say, step by step, a natural tendency toward co-operation and to the recognition of broader grounds of common interest, resulting in the tremendous increase in the efficiency of production, with lesser gains in the field of distribution or selling.

The objects of the Association are very well summed up in their motto: "All together all the time for everything electrical."

The Electrical Publicity Bureau, which was founded by the management of THE ELECTRICAL MAGAZINE some twelve months ago, is, in conjunction with Mr. R. Borlase Matthews, Wh. Ex., A.M.I.C.E., a gentleman of exceptional experience in modern methods as applied to the commercial development of electrical undertakings, moving along the lines indicated in the above article for the formation of a similar Association for Great Britain. Correspondence is cordially invited from Manufacturers, central station authorities, and all interested.

◆

The Industrial Power Problem.

WE have received the following letter from Messrs. DUFF BROTHERS & Co.:—

> We notice in this month's issue of the ELECTRICAL MAGAZINE, under your Editorial on the Industrial Power Problem, a statement by you that the Power Gas Corporation control the Duff patents in this country.
>
> As this statement is not in accordance with fact, and such a statement is calculated to damage our business, we beg to say that the Power-Gas Corporation do not own the Duff patent on which the name and fame of "Duff Gas" has been made. The name and fame of "Duff Gas" has been made chiefly by our Mr. E. J. Duff's invention of a gas producer patented in 1893, of prior date to the Mond patent which the Power-Gas Corporation have taken over. Many thousands of these producers have been built, and are in successful operation in all parts of the world.
>
> This patent is not owned by the Power-Gas Corporation, and never was. They have, however, a building right under it for Great Britain only, but not an exclusive right, and only for power-gas producers.
>
> Further, Duff Brothers own other patents for gas producers, under patents which are in no way controlled by the Power-Gas Corporation, and on which the reputation of "Duff Gas" is being built up. These producers are being built in all parts of the world, and none of these patents, either in Great Britain or abroad, are owned by the Power-Gas Corporation, who have no right or title whatever to the name of "Duff Gas" abroad, and, as we have indicated, have only a right to use it for the plants they build in Great Britain. We are unaware that they have ever sold any of these plants in Great Britain, as they have confined themselves to the building of Mond-gas producers in Great Britain.
>
> It is therefore manifestly unfair that all the Duff plants built before the time of the Power-Gas Corporation, under E. J. Duff's patent, and that the plants, under the same patent, which other people are entitled to build in Great Britain at the present time, should have the name of "Mond Gas" given to them, because Mond neither invented, designed, built, nor worked any of those installations. If this were so we should have an equal right to name all the gas generated in Mond producers as "Duff Gas."
>
> The use of what you call a generic term for gas from bituminous coal cannot be used in such a way as that suggested without misleading the public, and suggesting to them that Mond invented gas made from bituminous coal and that everyone else using bituminous coal is making "Mond Gas."
>
> Duff Gas is gas made in Duff producers; Mond Gas is gas made in a Mond producer; Dowson Gas is gas made in a Dowson producer; Crossley Gas is gas made in a Crossley producer; and so on. There can be no generic term for producer gas, as it was made long before either Duff or Mond was born. Siemens Gas is of world-wide fame and is widely used, and was probably the first practical producer using bituminous coal. Let each tub stand on its own bottom, and let Mond's claim of "Mond Gas" be limited to gas made in his own producer, and these are an infinitesimal number of the gas producers now used for bituminous coal, or at present under construction.

We have pleasure in publishing the above letter from Messrs. Duff Brothers & Co., in order to correct as far as possible any misunderstanding which may have arisen in the minds of our readers by the comments in our last number. It will be seen that the confliction of terms is responsible for the subject of contention.

Messrs. Duff express very clearly what they understand by the terms Duff Gas, Mond Gas, Siemens Gas, &c., basing their definitions on producers or plant. Mr. Esson in his address used the term Mond Gas as signifying that made by a certain chemical process irrespective of producers or plant, but Messrs. Duff explain that the same chemical process is used in both Duff and Mond producers, and that such chemical process was known prior to the inventions of either Mond or Duff, and that this chemical process is not now patentable nor can it be claimed for either party.

We can only leave it to our readers to decide for themselves which definition they prefer. In any case we are only too willing to give full publicity to Messrs. Duff & Co.'s protest, and couple with it our regrets that this possibility of misunderstanding should have developed.

* * *

The Channel Tunnel.

THE revived proposal to drive a tunnel below the English Channel and so place Britain in dry-land communication with the Continent is a subject of great international moment, and is naturally exciting considerable popular interest. Whether the bill seeking for its authorization which was deposited in Parliament last month will pass or not is largely a matter of conjecture, there being already a very keen opposition. Should this scheme be actually decided upon, of course electricity will be the power of locomotion of the sub-Channel railway, and doubtless it will form the most important of any electrical traction system in the world, not because of its length, but because of its international character and the enormous traffic which it will be called upon to cope with. The daily papers are all giving their best space to discussion as to the advisability of encouraging the proposal. We have not space at this writing to express at length the reasons for and against, but we expect to return to the subject in an early issue. There is one significant fact which may be taken as of extreme importance, namely, that the opposition to the scheme is almost entirely limited to this side of the Channel. The Continental peoples are strongly in favour of the work going forward. Our readers will not require to study the question very closely from a commercial standpoint before they will arrive at the reason for this want of balance of opinion on the two sides of the Channel.

It is estimated that the scheme will involve a total outlay of £16,000,000. Half of that amount is to be raised in this country, and the remainder is promised in France, as soon as the scheme shall have received Parliamentary sanction in England.

Two parallel tunnels will be constructed, the total length of the same under the sea being 24 miles and, with the land approaches on either side, 30 miles.

The tunnels, each 18ft. in internal diameter, will be driven from Dover to Sangatte, throughout the whole distance in the grey Rouen chalk, which, 87ft. thick on the English side and 80ft. on the French side, is a stratum very homogeneous, practically free from and remarkably impervious to water.

Power from the electric motors which are to be employed in the tunnel traffic will be obtained from large generating stations, which are likewise to supply the current required for lighting as well as the compressed air necessary for the purposes of ventilation. When the trunk line now in course of construction through Greece has been completed the opening of the Channel Tunnel, will, it is said, shorten the mail route to India by twenty-six hours.

LISTEN to these points!

Point 1.—You cannot peruse all the Electrical Journals published and you want to keep up to date.

THE ELECTRICAL MAGAZINE will present during the current year, in addition to original matter, a précis of all the most important articles published in every trade and industrial journal on Electrical subjects.

Point 2.—You often require particular information of a special and exclusive character which you cannot get through the ordinary channels, and you sometimes want it quickly.

*Annual subscribers booking **now** for this year have access to the INTELLIGENCE DEPARTMENT, attached to this Journal, which is able to and will supply such subscribers with information on any subject asked for **FREE OF COST and at any time.***

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See other particulars and subscription form at end of this issue.

POWER: and its application to INDUSTRY

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Power, its Generation, Transmission, and Distribution.

Progress in Electric Power.

THE most important phase of electrical power engineering of the present day is that which has to do with the centralization of generating plant; the tendency of the times is to erect single works, of enormous capacity, so equipped and situated as to give the highest economy of generation. From these huge works energy in bulk is transmitted at extra high electrical pressures to various high-power sub-stations, and thence distributed over very wide areas.

Of these schemes the most widely known is that brought forward by the London County Council, which appeared as a Parliamentary Bill last year, and which it is intended shall come forward again this year in that form, the difference being that the modern proposal is even more extensive than the first. It is the desire of the L.C.C. to supply power, not only to the whole of London and its suburbs, but also over a very considerable area of the surrounding country. It is impossible at this time to say whether the L.C.C. are likely to gain the necessary powers for this, the most extensive electric power scheme, or not. It is significant, however, that if they do not succeed in their effort to gain the Imperial consent, there are private parties who are prepared to take up London's burden in this sense.

Of the provincial power schemes in operation, good reports are generally found. The Newcastle Electric Supply Company is flourishing; the new power system of the year, the North Wales Power and Traction Company, which is our only example of high-power hydro-electric generation, is distinctly progressing. This installation consists of four turbo-alternator sets: the available head of water is 1100ft., and current is generated as three-phase, 10,000 volts, 50 periods. Each generating set is of 1500h.p. capacity. The field of supply includes many quarries and general works in the neighbourhood, and these are fed by overhead transmission lines.

A similar system is that of the Lancashire Electric Power Company, who started their supply in 1905. In this case also the transmission is three-phase, 10,000 volts, 50 periods, whilst the generating plant consists of steam-turbine-driven sets of an aggregate capacity of 8000kw.

Regarding the applications of electric power it is impossible to select any one or other of the numerous installations for special mention. The increase in this branch of work has been far above the average, the motor builders having had an exceptionally prosperous year. Electric power has indeed become the standard for all workshop and factory purposes. In mining and heavier works practice, where electrical development has always been slowest, the past year has witnessed great advances.

As following the tendency to concentrate power-generating plant at a few centres of huge aggregate power, there is the corresponding increase of transmission pressures. It may now be considered quite usual to employ voltages well into the tens of thousands. From what has been said it will be seen that 10,000 volts transmission is in regular standard use in this country. There are several systems abroad using voltages of over 50,000. The latest proposal is that of the Victoria Falls Power Company, as dealt with in the last number of THE ELECTRICAL MAGAZINE, to use 150,000 volts on the transmission lines. It is perhaps too early to consider the bearing which this last system may have on present practice, but the fact is well established that extra high tensions are the order of the day in matters electrical, and manufacturers and students alike may take it that this branch of the electrical industry is certain in its prospects. The past year's records contain a large store of research and invention in extra high tension phenomena and apparatus. In America and on the Continent, as well as in this country, many of the most able electrical men of the day are engaged in perfecting extra high tension plant, their work covering the whole scale from immense generating units and transformers down to line insulators. An outstanding feature of this work is the skill which is being brought into the design of switchgear. In this connection practice has reverted to the use of oil as the insulator and blow-out; but there is no comparison between present-day oil-type apparatus and those used in the pioneer days of the eighties. There is the further feature of distant and isolated control of high-tension apparatus by local low-tension circuits and relays, in conjunction with time-element automatic operation, which represents the high-water mark of switch manufacture and ingenuity. The cable manufacturers, too, moving with the times, are supplying underground mains for pressures which, not so very many months ago, were thought to be prohibitive.

With regard to prime movers in electrical power service there is nothing startling in last year's practice. Steam power remains in the ascendant; steam turbines are favourites still, but only for the higher-powered units; the reciprocating engine is holding its own in all other cases. We had thought that the past year would have seen large gas-power units established on a firm footing; there has been only little progress in this direction. The largest gas engines in this country are still those which operate with blast-furnace gas, and their power is mainly taken up in driving blowers. What will come, and perhaps this year will bring great steps in this direction, is the general adoption of patent coking ovens at collieries and ironworks; these will be accompanied by gas-driven electrical plant, possibly in units, or an aggregate of units at one centre, larger than any existing under present conditions. There is no doubt as to this method of power generation, when established on a sufficiently large but yet practical scale, being far and away the most economical; it is due to conditions of locality only that it has not yet asserted itself to the exclusion of all other systems. The collieries have had an extremely prosperous year—coke is dearer now in some parts of this country than it has ever been before: perhaps some of the largest colliery owners will this year be tempted to invest in patent coke-oven gas-electric plants, and so establish a fashion which is certain to become standard sooner or later for electrical power service in this country.

From the consideration of huge generating works one is lead to the other extreme and finds that great progress is being made in the use of small self-contained plants for isolated installations. In these cases gas power has definitely established itself and is fast becoming the standard. The suction producer, the gas engine, and the dynamo are to-day as readily understood and attended to by the gardener or handy man about the place as is the greenhouse stove. The gas-electric plant is simple and reliable, and moreover it is certainly the cheapest means of generating current even in comparatively small quantities—an average cost of about one-tenth of a penny per horse-power-hour cannot be claimed for any other coal-consuming power system. The large number of firms who have lately taken up the manufacture of combined suction producers and engines is evidence of a great demand, and these firms are all kept busy.

There is quite a distinct tendency towards the introduction of electricity in isolated farm-houses and remote hamlets. In many of these places the local conditions of place and purse will not allow of coal being used at all, and developments are being made in applying the powers of the wind and the stream for generating electricity. Five horse power or so goes a long way as a labour-saver on the farmstead; threshing, chaff-cutting, grinding fodder, churning, sawing, &c., are all admirable services for the electric motor: a windmill plant to serve this purpose is remarkably cheap. When this is backed up by a small oil engine as stand-by, the power supply becomes always available, and has proved to be a remarkable source of economy even on this small power scale. There are capable engineers in this country engaged in perfecting the details of these small cheap plants; the agriculturist who keeps his eyes open will very shortly find that an electrical installation of his own is an essential of modern farming.

Speaking of small powers, there is apparent an ever-increasing demand from the householder and hotel proprietor for tiny motors of sizes from one horse power downwards. These are becoming great favourites for the driving of sewing machines, knife-cleaners, boot-polishers; also in the lighter trades they are very generally used for coffee-roasters, sausage making, boot stitching and finishing, smiths' blowers, light hoists, &c. The result has been a great improvement in the design of small electric motors, and to-day there are many prosperous firms engaged solely in their manufacture.

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Automatic Electric Pumps for Railway Tank Supply.

A successful induction motor-driven pumping plant for supplying water tanks is in operation on the Lake Shore and Michigan Southern Railway, at South Bend, Ind. The pumping outfit consists of two single-stage turbine pumps, each direct-connected to a six-pole 7½h.p. three-phase 440-volt induction motor. Two pumping sets are installed, so that in case one set fails repairs can be made without shutting down the plant. Power for operating the induction motors is taken from the public supply.

The pumping house is a round brick structure, erected at the top of a concrete-lined wall. The floor is of concrete, supported by I-beams, and is 10ft. below the level of the ground. On this the pumps are erected, and for keeping the pump-room dry four ventilating ducts are built into the wall of the pump-house.

Each pump discharges water through a 2½in. pipe connecting with a 4in. main which leads to the supply tank. This tank is located at the side of the tracks about 100ft. from the pumping station. The controlling device is arranged in the housing on the roof, the motors being started and stopped automatically by a small oil-switch operated by a float which has a vertical movement of about 1ft. The difference in level in the tank corresponds to 3000 gallons of water. This is the average amount taken by a locomotive, and is replenished by the pumping set in about twenty-five minutes. The supply tank holds about 50,000 gallons, and could supply fifteen locomotives within a few minutes if necessary. However, such a heavy demand will probably never be made, and in actual practice the pumps stand idle for the greater part of the time.—*Elec. Rev., N.Y.*

◆

Very High Tension Transmission.

The results of experiments by E. Jona in the handling and transmission of currents of exceptionally high pressures have been published in a recent issue of *L'Industrie Electrique.* The supply source consisted of a 150kw. transformer having a primary wound for 160 volts, and having two sets of secondary coils each giving a pressure of 160,000 volts; therefore with the secondaries in series a tension of 320,000 volts was available. The voltages were measured by an electrostatic voltmeter which read up to 200,000 volts; for the higher readings this instrument was connected across only one of the secondaries. Tests were made on a cable 400ft. long and consisting of a nineteen-strand core about 18mm. in diameter, insulated with successive layers of rubber and paper up to a diameter of 48mm., the whole being lead-covered. This cable, in the form of two coils, was connected to the transformer and used as the two lines of a transmission system at 160,000 volts, the current being used to light a number of vacuum tubes. Samples of this cable were tested by means of the transformer for the breakdown voltage. Lengths of from 15ft. to 20ft. in length were prepared by stripping back the lead sheathing and covering the exposed insulation with resin and porcelain tubes. The terminals of the transformer were then connected to the remaining portion of the lead sheathing and the core, and the voltage increased until the dielectric was perforated. This occurred for three samples at 208,000, 202,000, and 210,000 volts respectively. Other tests were made of a high-tension cable recently constructed for a 13,000-volt three-phase circuit laid on the bottom of Lake Garde. The circuit consists of three single-core cables. The conductor is stranded, and has an equivalent cross-section of 75 square mm. This is insulated by layers of rubber 5mm. thick and gutta percha 1.2mm. thick. This is then covered by a lead sheathing, followed by a layer of jute and an armour of fifteen steel wires covered by a jute wrapping. The samples of this cable used in the tests were 9ft. long, and they withstood successfully a tension of 100,000 volts, which was the maximum that could be applied on account of the violent sparking which took place from the steel armour along over the surface of the insulation to the core.

The transformer was also used for experiments with an overhead line carried on large porcelain insulators. Two thicknesses of wire were used, one 70mm., which gave brush discharges at 50,000 volts, and another, 100mm. in section, showed the same phenomenon at 100,000 volts. The pressure in the latter case was increased up to 280,000 volts, at which point the discharge was brilliant, and flashes took place across the line and over the insulators.

Another interesting experiment consisted in applying the voltage of 90,000 to a spark gap about 10in. long. The latter was mounted on the axle of a small induction motor driven by the same supply. When the circuit was closed sharp discharges took place between the terminals, which were quickly put out, due to their motion. The result was a series of discharges having the appearance of a sort of cage revolving slowly in a direction opposite to the rotation of the motor, and at a speed approximately equal to its slip.

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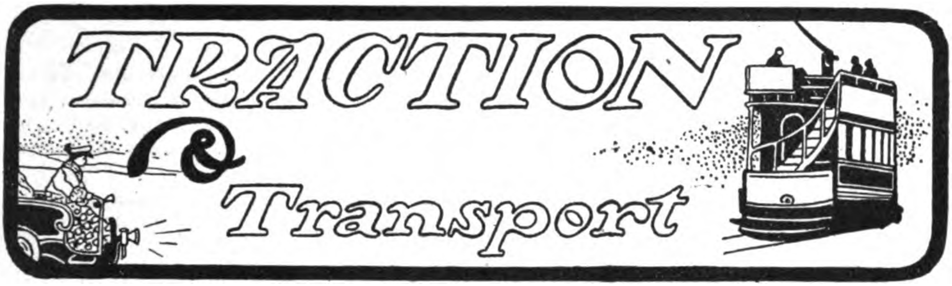
Electric Power in Copper Production.

FOUR large induction motors have been purchased for the equipment of the 10,000-ton concentrator of the Washoe smelter, a new portion of the $9,000,000 reduction plant of the Anaconda Copper Mining Company at Anaconda, Mont. This plant is to operate with power supplied by the two stations of the Helena Power Transmission Company, on the Missouri river near Helena, nearly 100 miles from Anaconda. Formerly all the power required was supplied by steam engines, and a certain amount of steam power will probably always be used, as some of the steam boilers utilize the heat contained in the waste gases from the furnaces. However, this power, obtained from a by-product, is not nearly sufficient to operate the whole plant, and all additional power will ultimately be supplied by electricity.

The concentration building is 600ft. long, with the steam plant heretofore used for driving it located in the centre. It is intended to leave this steam plant intact, to be used as a reserve in case the electric power fails, and to disconnect the shaft at each side where it enters the engine room, thus dividing the shaft into three parts, a live section on each side of the engine room. The mill as a whole is divided into eight sections, four on each side of the engine room. Two induction motors will be installed in each half of the mill, and connected to the main shaft by rope drive and friction-clutch pulleys. Each motor is capable of 1200h.p. output at 360 revolutions per minute synchronous speed.

These large motors are notable not only on account of their high power, but also because of their having squirrel-cage rotors, which is unusual in motors of this size. Their guaranteed full-load efficiency is 91 per cent. and full-load power factor 92 per cent. Squirrel-cage motors were chosen for this installation because the conditions under which they have to start are favourable and also because of the high power factor of this kind of motor as compared with the wound-rotor type. The motors, being connected through friction clutches, start up light and, as the mill runs continuously, it is not expected that the motors will need to be started frequently. It is claimed that tests show that these motors exceed the guaranteed power factor of 92 per cent., and that the starting current taken from the line will not exceed full-load running current when starting the motor with its rope drive and friction pulley connected. Starting is effected by an oil-immersed controller connected to an auto-transformer which lowers the applied voltage at starting. The controller has six steps so that the motor can be brought up to speed gradually.—*Power.*



A classified list of Traction and Transport articles will be found in the World's Electrical Literature section.

Electric Traction Development.

THE past year has witnessed noteworthy progress in the electrical propulsion of vehicles on street tramways and on heavy railways. Methods for the former service are practically standardised to the use of direct-current, overhead trolley conductors and track-rail return circuits; for the latter service the respective merits of direct current and alternating current have still to be finally decided in practice. In this country there are many direct-current railways which have been in operation for years; the present year will probably see the inauguration of alternate-current railway operation with the completion of the London, Brighton and South Coast Railway Company's conversion of the railway between Victoria and London Bridge, whereon good progress is being made. Another example of alternate-current traction which is now under construction is that of the Midland Railway Company, which is to connect their new Heysham Harbour with the town of Morecambe. There are other electrification schemes resolved upon and proposed by our main line companies, one of these being for the construction of an entirely new railway system by the London and North Western Company to duplicate their line between Euston and Watford.

The Great Northern, Piccadilly, and Brompton Railway.

Of heavy electric traction work there is none which is attracting such world-wide attention as the underground electric railways of London. The map herewith shows the extensive scale on which these developments are being effected. The late Mr. C. T. Yerkes founded the Underground Electric Railways Company of London about five years ago. Their work was to construct three great tube railways: the Baker Street and Waterloo Railway; the Great Northern, Piccadilly, and Brompton Railway; and the Charing Cross, Euston, and Hampstead Railway. The first of these has been completed and in full operation for some time past; the second has just been opened for public service, and the third and last link of this enormous system will be completed during the summer of this year. When one considers the huge amount of capital sunk in these railways, one realises forcibly the gigantic effort of a few short years.

The Great Northern, Piccadilly, and Brompton Railway—London's latest and longest tube—was opened for traffic on December 15th last year. The total authorised capital of this line is £7,206,000, and considering the expenditure—£5,738,240—up to June 30th last, it was estimated that this capital would complete the system, making the total cost of construction and equipment approximately £800,000 per mile.

The excavation work started in July, 1902. The tunnels are driven through the London clay and are lined with cast-iron segments in the now well-known style of tube construction. The line is about nine miles long, all underground with the exception of about 1300 yards at the Hammersmith end. Double tracks are laid throughout; the respective sections of the tube in the straight and at stations are shown in Fig. 2. On

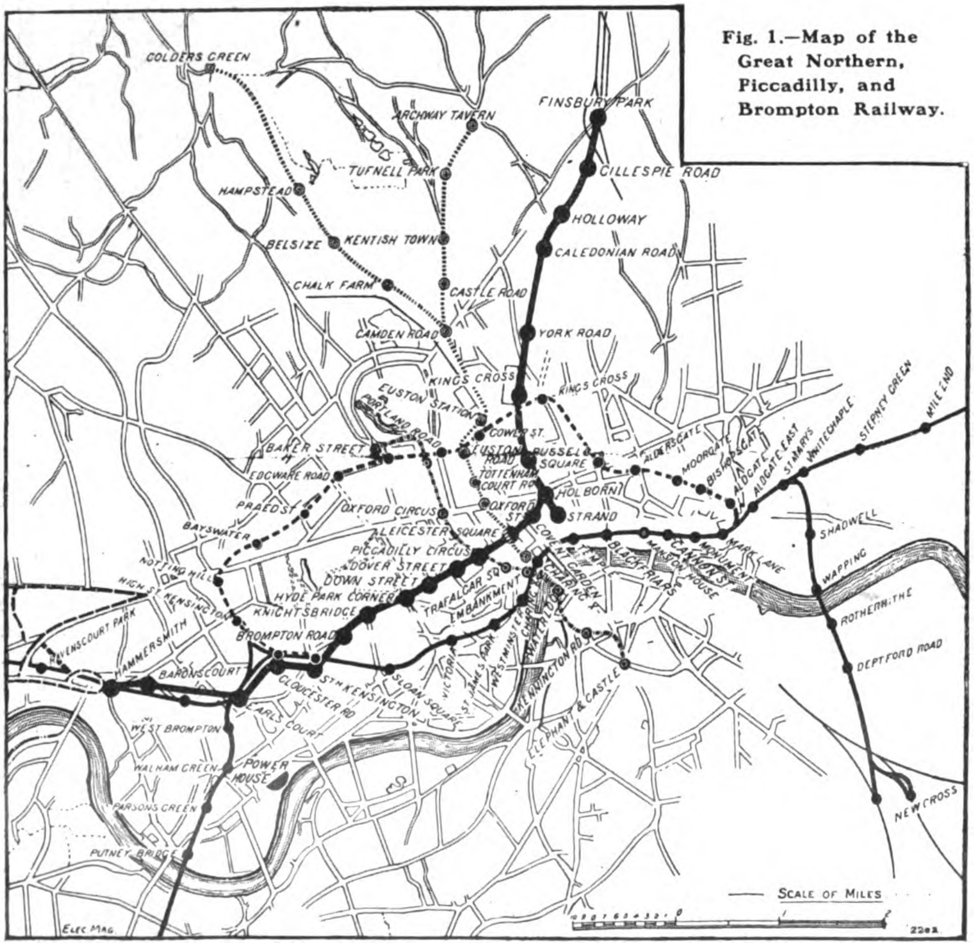


Fig. 1.—Map of the Great Northern, Piccadilly, and Brompton Railway.

Great Northern, Piccadilly, and Brompton Railway	━━●
Metropolitan-District Railway, and its Running Powers	──●
Metropolitan Railway, over which the District has Running Powers	▬▬▬●
Charing Cross, Euston, and Hampstead Railway	••••••⊖
Baker Street and Waterloo Railway	•▬▬•⊖
London United Electric Tramways	☰

curves of less than 10 chains radius the tube diameter is increased by 10in., that is, up to 12ft. 6in.; on wider curves the tube is increased by 4in. The diameter of the tube at the stations is 21ft. 2½in. The relative position of the tubes varies considerably. In some cases they are side by side, in others vertically above each other. For instance, at the South Kensington station one tube is 18ft. below the other one. These variations were necessary owing to the limitations of streets and buildings on the surface. The general contour of the line is a fall between Finsbury Park and Holborn. Onwards the line is practically level to Earl's Court, from which point it rises to Hammersmith. These gradients are not so severe as to influence the design of the motor equipments, the heaviest gradients being those intentionally introduced between stations. As is usual in tube railway practice, gradients are purposely made so that they help the acceleration of trains on leaving the station, and assist in retarding on approaching the stations. The former have a grade of about 1 in 33, the latter about 1 in 66. The greatest depth of the tube is at Covent Garden Station, which is 123ft. below the

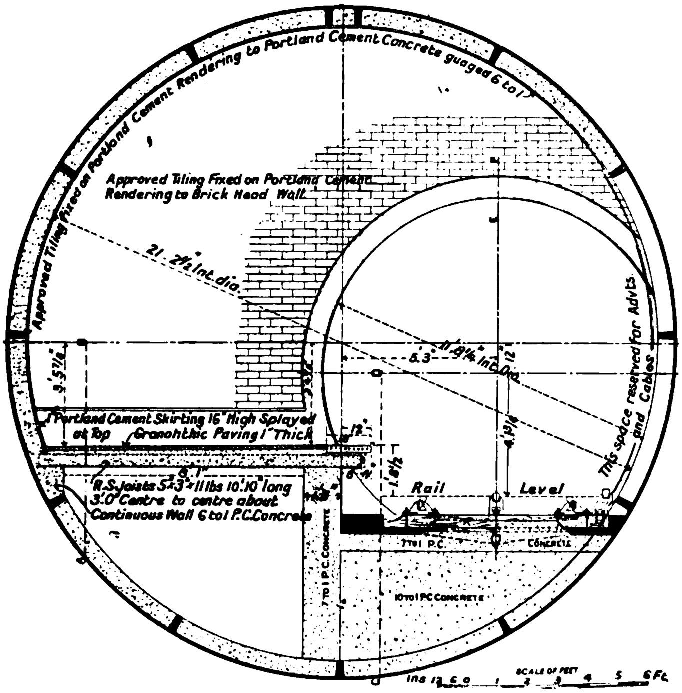

Approved Tiling Fixed on Portland Cement Rendering to Portland Cement Concrete guaged 6 to 1
Approved Tiling Fixed on Portland Cement Rendering to Brick Head Wall
21. 2½ Int. dia.
11. 8¼" Int. Dia.
5.3"
12"
9.5⅞"
3.6½"
4.13⁄16"
1.8½
12"
6.1"
Portland Cement Skirting 16" High Splayed at Top
Granolithic Paving 1" Thick
R.S. Joists 5"×3"×11lbs 10.10" long 3.0" Centre to centre about
Continuous Wall 6 to 1 P.C. Concrete
7 to 1 P.C. Concrete
Rail Level
7 to 1 P.C. Concrete
10 to 1 P.C. Concrete
This space reserved for Advts. and Cables
Ins 12 6 0 1 2 3 4 5 6 Ft.
Scale of Feet

Fig. 2.—Cross Section of Tunnel in Straight and at Station.

street level; at the Hammersmith end the line comes to the surface, as already said; at Finsbury Park the station is only 20ft. below the street. A good general idea of the track construction will be gathered from illustration Fig. 4. The gauge is standard; the track rails of 90lb. per yard. The chairs weigh 30lb. and have a layer of pressed wood felt ¼in. thick between them and the karri wood sleepers. The latter are 6ft. 6in. long by 14in. by 5in. The chairs are secured by screws insulated from metallic contact with the chairs by vulcanised fibre bushings and washers.

The conductor rails are of rectangular section; they weigh 85lb. per yard, and are supported on insulators of Doulton earthenware. The track is ballasted with ⅜in. granite cubes, and the slight drainage necessary is provided for by means of cross gutters leading to a 3in. pipe embedded in the concrete which lines the bottom part of the tube.

The power supply of the railway is received from the immense Chelsea station of the Underground Electric Railway Company of London. This world-famed installation is familiar to all electrical men, and need not be described here. The power, as generated by Westinghouse turbo-alternators of 5500kw. capacity each, is transmitted at 11,000 volts, 3-phase, 33⅓ periods, to three sub-stations situated respectively at Hyde Park Corner, Russell Square, and Holloway. These sub-stations have all been equipped by the British Westinghouse Company; the one at Hyde Park Corner contains three rotary converters of 800kw. each, the other two are each equipped with two converter sets of 1200kw. each. The direct-current line pressure varies from

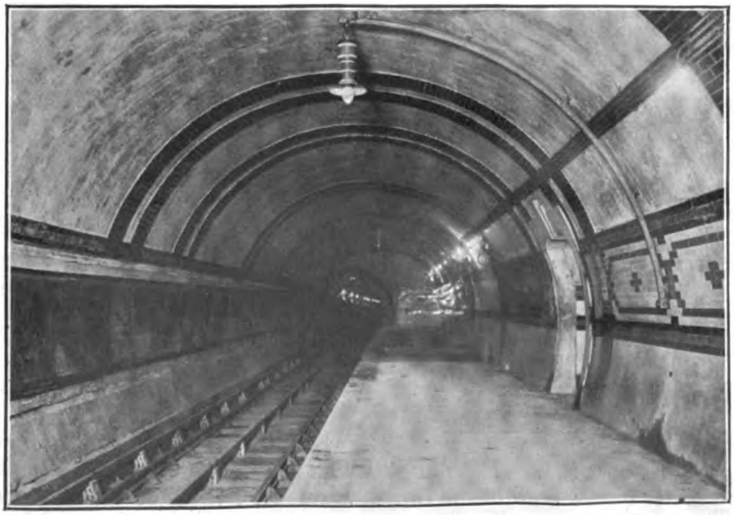


Fig. 3.—General View of a Station Interior.

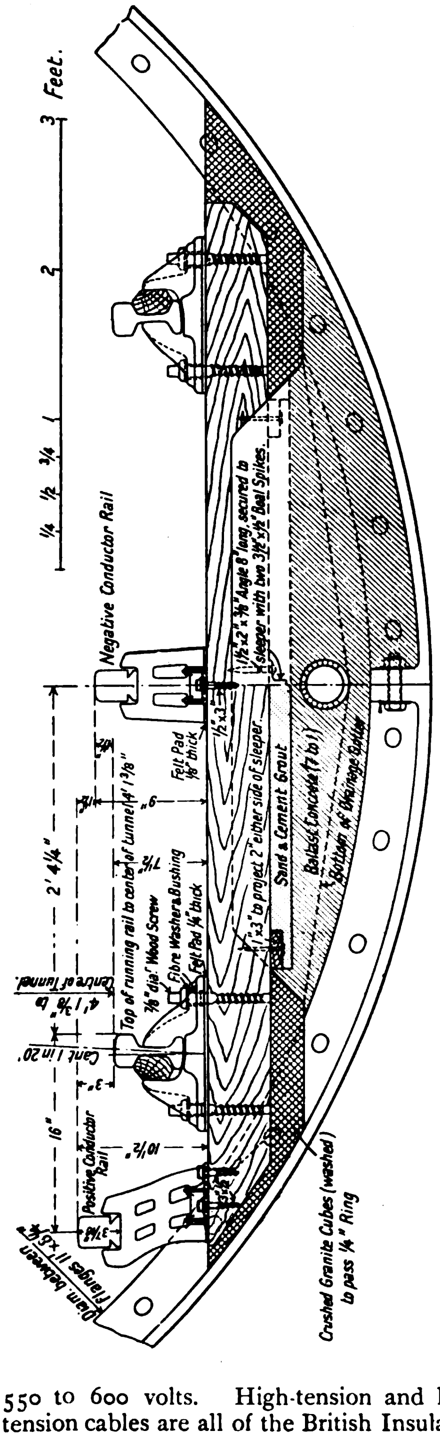


Fig. 4.—Section through Lower Segment of Tunnel, showing Track and Conductors.

550 to 600 volts. High-tension and low-tension cables are all of the British Insulated type.

Limitations of space prevent our entering fully into the many details of this latest and most important of London's underground railways. We should, however, mention that everything underground has been made as far as ever possible of fireproof construction. The rolling stock is all of continental manufacture. The car bodies are of steel, and although they appear inside to be panelled with mahogany, this is nothing more than a veneer of comparatively paper thickness, and even this has been treated so as to make it uninflammable. The electrical equipment of the rolling stock was supplied by the British Thomson-Houston Company, the trains being operated and controlled on the well-known B.T.H.-Sprague multiple-unit system. The equipment of a motor car is very clearly shown in the illustration, Fig. 5, which, as will be seen, was obtained by taking out the side panels of the car. The motors themselves are of 200h.p. each, there being two fitted to each motor car. The weight of a motor car complete is 27½ tons, and of a trailer 16½ tons. The line has commenced its public service with twenty-six trains of three cars each. The standard train will, however, be made up of six cars, and these will be brought into use as the traffic requirements demand. The braking system adopted is the well-known Westinghouse air-brake system. It is of further interest to note that the complete signalling plant is all of the Westinghouse electro-pneumatic type, partly automatic, and on other sections hand-controlled.

There are nineteen electrically driven fans, 5ft. 6in. in diameter, 250r.p.m., driven by 10h.p. motors installed for ventilating the tunnels. These were supplied by Heenan & Froude, and each draws 18,500 cubic feet of air per minute from the tunnel. The fans are installed in the surface buildings, and are connected with air ducts of 16 square feet section to the tunnels. The surface buildings of the stations follow the general design which has become familiar to all in connection with the Baker Street and Waterloo line. The stations proper below ground are beautifully finished in enamelled brickwork, and their lighting is particularly pleasing and effective. The lamps used throughout are of the well-known Maxim type, some few particulars and an illustration of which will be found in another part of this number. As a proof of the reliability of this particular lamp the fact that it has been adopted on every new

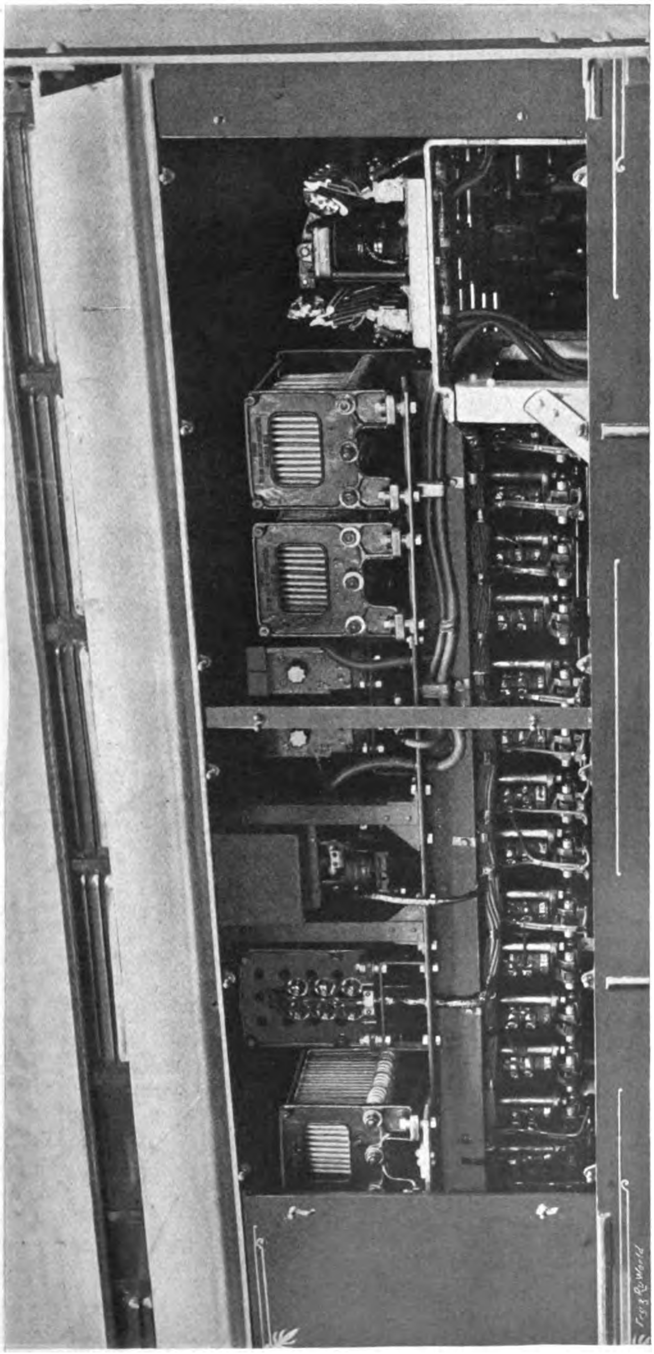


Fig. 5.—View of the Electrical Apparatus in Motorman's Cab.

electric railway in London since it was first taken up by the Metropolitan District on its conversion to electrical traction speaks for itself.

For detailed descriptions of the complete railway, readers should refer to our World's Electrical Literature Section, where they will find references to contemporaries who have published full particulars of this line. We ourselves have to acknowledge our indebtedness to *The Tramway and Railway World* for their kindness in placing illustrations Nos. 2, 4 and 5 at our disposal, and also to *The Railway Gazette* for illustration No. 3.

Tests of Ward-Leonard-Oerlikon Locomotive.

The Oerlikon Machine Works, of Switzerland, have recently made public the results of certain tests conducted on the Ward-Leonard-Oerlikon electric locomotive. The Oerlikon Company builds all classes of electric locomotives, and recommends this type under two conditions, viz.: (1) When the profile is irregular so that recuperation can be secured either in one or both directions of running, and (2) when it is desirable to economize power and when there are frequent stops.

Up to July 1906 the locomotive tested had been in regular service for two years on a section of the Swiss Government Railway between Wettingen and Affoltern. The haulage during that time was 434,000 ton

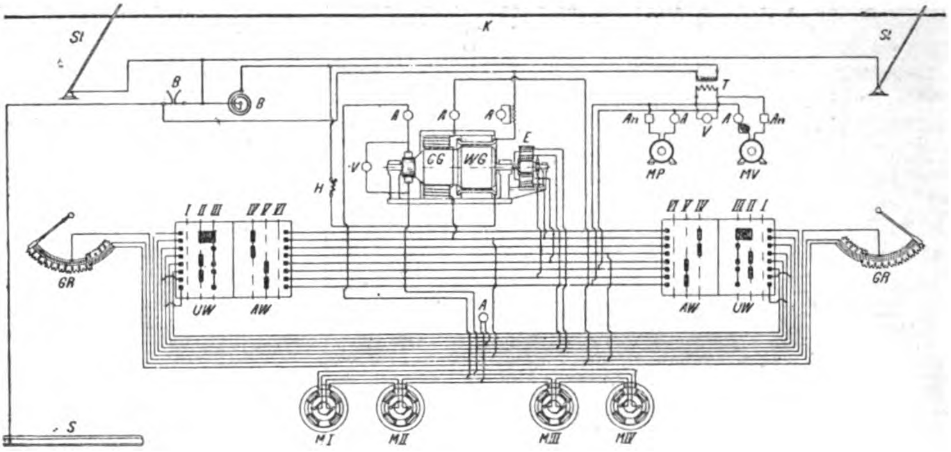


Fig. 1. Diagram of Connections of Locomotive.

K—Trolley wire.
St—Trolley.
B—Lightning arrester.
H—High-tension circuit-breaker.
A—Ammeter.
V—Voltmeter.
WG—Single-phase motor.
GG—D.C. generator.
E—Exciter.
T—Transformer.
An—Switch.
MP—Motor-Compressor for air-brakes.
MV—Low-pressure pump for air blast.
GR—Regulating resistance for speed.
AW—First half of controller (for starting).
UW—Second half of controller (for changing connections).
MI, MII, MIII, MIV—D.C. motors on axle.
S—Rail.

miles. The single-phase voltage used was 15,000. During the two years no repairs of any kind have been required; the only change made in the equipment has been that the machine was originally built for 50 cycles, and after some runs had been made it was decided to change the frequency to 15 cycles; the alteration required in the locomotive was to rewind the stator of the induction motor. This fact shows the flexibility of this type of machine to different conditions of service. The locomotive weighs from 44 to 46.5 metric tons, and is capable of a tractive effort of from 1320lb. to 8800lb. at speeds of from 44 to 22½ miles per hour. Twenty-five cycle current is considered by the manufacturers as "standard" for this type of machine, but, as stated, frequencies of 50 cycles and 15 cycles have been used satisfactorily.

The voltage of the single-phase current may also be regulated by local conditions. With 6000 volts on the trolley wire the current is taken directly to the motor-generator group, and the weight of the locomotive complete is 44 metric tons. When the trolley wire potential is above 6000 a transformer is used. The weight of the locomotive is then increased to 46.5 metric tons.

The weights of the two types of locomotives, and prices quoted for them by the manufacturers, are approximately as shown in the following table.

A—ELECTRICAL EQUIPMENT.

	6000 Volts and 25 Cycles.		15,000 Volts and 25 Cycles.	
	Weight, Kg.	Price, Francs.	Weight, Kg.	Price, Francs.
Motor-generator, with exciter, controller, and rheostats	15,180	40,500	15,180	40,500
Four d.c. motors	8,000	25,700	8,000	25,700
Collector, high-tension switch, ammeters, voltmeters, lightning arresters, lightning apparatus, and wiring .. .	560	4,100	560	4,100
Transformer, with blower, compressor, compressor governor, tools, etc. ..	1,360	4 200	3 960	10,700
Total for electrical equipment.. ..	25,100	74,500	27,200	81,000

B—MECHANICAL EQUIPMENT.

Two trucks, with wheels, 1 meter diameter, locomotive body and cab ..	19,000	23,000	19,000	23,000
Total	44,100 or 97,020lb.	97,500 or $19,500	46,200 or 101,640lb.	104,000 or $20,800

The motor-generator group, with the exception of the primary side, is the same in both equipments. It consists, briefly, of a single-phase induction motor whose armature is mounted on the same shaft as the armature of the d.c. generator and of the exciter. The latter machine also serves as a starter, as will be described later. The common shaft

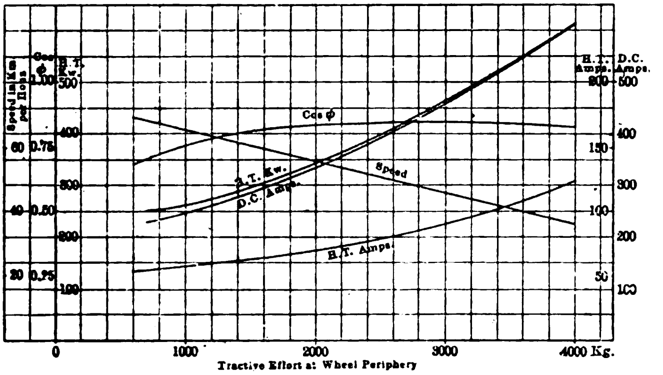


FIG. 2. CHARACTERISTIC CURVES OF LOCOMOTIVE. DIRECT CURRENT CONSTANT AT 900 VOLTS.

runs at 730r.p.m. The rated power available at the shaft is 520h.p., and the maximum is 1100h.p. The railway motors are also the same in the two equipments. They are wound for independent excitation, and are provided with artificial ventilation and encased to keep out the dust and moisture. They are designed for 900 volts and a maximum speed of 1200r.p.m. The continuous output available for each motor is 95h.p. Each, however, is capable of working up to a maximum of 200h.p., measured at the rails and including the gearing, which is in the ratio of 1 : 3.5. Fig. 1 shows the diagram of connections.

To start the locomotive, the motor-generator is first put in operation. This is accomplished through step 5 of the controller by which the secondary of the 10-KVA transformer is connected to a special transformer coil on the exciter, which is in series with its armature, so that the exciter operates as a single-phase series motor, and brings the motor-generator up to the normal speed. When this is accomplished the stator winding of the motor of the group is connected to the single-phase line current by means of a high-tension switch. In the next position, step 4 of the controller, the field coils of the d.c. generator are connected to the poles of the exciter, whose series starting coil has been cut out, and which now runs as a shunt dynamo auto-exciter. The exciter then supplies current to the field coils of the generator part of the motor-generator, and also to the field coils of the railway motors. These two circuits include regulating resistances, which are controlled by a lever with a common contact point.

We have now to consider the other two positions of the controller cylinder. These steps change the connections of the exciter; in one position the current passes through the field coils of the railway motors in one direction, and in the other position in the reverse direction. As the direction of the current from the generator remains constant, these two positions of the controller give direction to the locomotive. Variations in speed are made by varying the resistances in the field circuit of the generator and in the field circuits of the motors. Recuperation of energy is secured by means of the rheostats of the field circuits of the motors, through which the voltage at the brushes of the motors can be made greater than the voltage at the poles of the generator. The motor-generator then revolves at a higher speed than would be called for by synchronism, and the single-phase motor of the group pumps back current into the line.

Fig. 2 shows characteristic curves of the locomotive when operating under normal conditions. In this diagram the speed curve is shown as a function of the tractive effort for different drawbar pulls of the locomotive, such, for instance, as would be required by

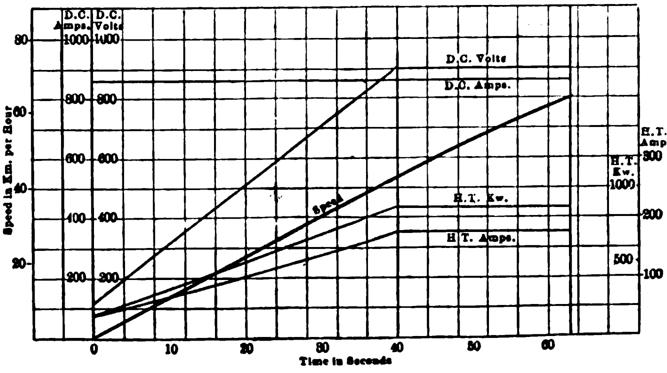


FIG 3. STARTING WITH 170-TON TRAIN ON LEVEL.

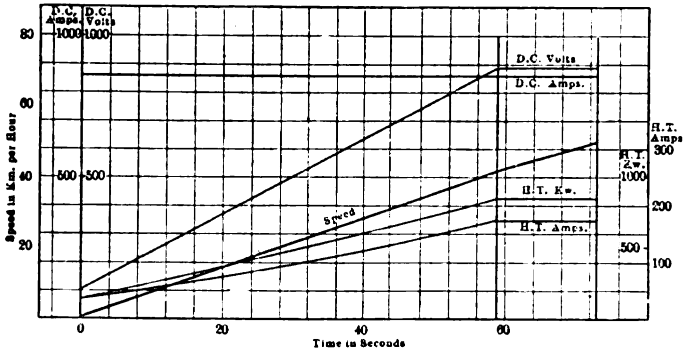


FIG. 4. STARTING WITH 170-TON TRAIN ON ONE PER CENT. GRADE.

a train on various percentages of grades. The d. c. motors are usually run at a constant voltage of 900, the exciting current being varied to secure changes in speed. Nothing would prevent, of course, obtaining different speeds by varying the voltage applied to the motors, but in this case the draw-bar pull of the locomotive would be limited by the maximum voltage available. For normal operation, therefore, it was considered undesirable to change the voltage of the motors. It is otherwise, however, in accelerating the train, when the most economical results are secured if at first the voltage of the motors is varied and afterwards kept constant.

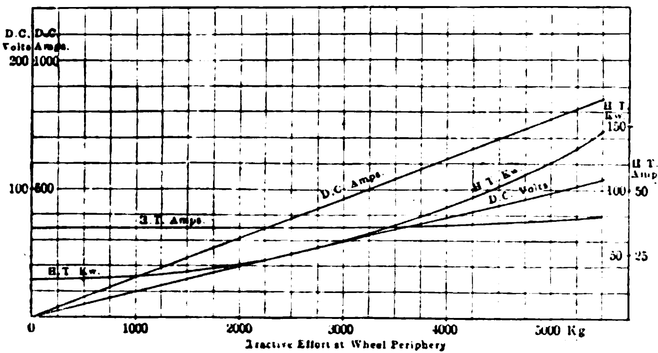


FIG. 5. MAXIMUM TRACTIVE EFFORT AT START OF ACCELERATION.

Figs. 3 and 4 show acceleration curves for a train weighing 170 tons. In Fig. 3 the acceleration occurs on the level, and in Fig. 4 on a grade of 1 per cent.

In Fig. 5 are assembled the maximum tractive efforts developed at the commencement of a period of acceleration, with the corresponding electric characteristics. Although in this diagram the field strength of the motors is assumed to be constant and at a maximum, different tractive efforts are developed by varying the voltage at the poles of the d.c. armature of the motor-generator group. It is also possible to obtain from Fig. 5 the values of the constant losses of the motor-generator group when running without load, that is 28kw., as well as the current absorbed without load, 34.5 amps., for a voltage on the trolley wire of 6000. The amount of power consumed under different loads as well as the power factor of the single-phase motor are shown at different speeds in Fig. 2. In Fig. 5 it is possible to obtain the same values for the locomotive in a stationary position, the generator being differently excited according to the different degrees of starting desired. Finally, these same values are also shown in Figs. 3 and 4 during the period of acceleration of a train of 170 tons on grades of 0 and 1 per cent.

As to the recuperation of energy by electric braking, it can be shown that on the level the energy which can be recuperated in reducing the speed of a 170-ton train from 41 to 17 miles per hour in 52.5 seconds will be about 3kw. hours, and the power recuperated by keeping the speed of the same train constant at 41 miles per hour on a 1 per cent. grade is 63h.p.—*Street Rly. Journal.*

The ELECTRICAL MAGAZINE offers Manufacturers of Electrical Plant and Apparatus the most Economical, Direct, Forceful, and Convincing Publicity for 1907.

Central Station Practice

The World's Electrical Literature Section contains a classified list of all articles of interest to Central Station men. CONSULT IT and save yourself much valuable time.

Central Station Progress.

The engineering aspect of central station practice is dealt with in the Electrical Power Section. There is, however, one outstanding feature of the public electric supply practice of the past year which merits particular attention. It is the phenomenal development of the commercial side of this business. Our opinions as to the necessity of organization in this matter are stronger than ever—success in certain specific instances proves that we are on the right track.

In connection with THE ELECTRICAL MAGAZINE a distinct organization known as the "Electrical Publicity Bureau" came into being with the past year, which has as its primary object the furtherance of the use of electricity, and therefore the advancement of central station business. A very definite part of this work consisted of the introduction of the journal POPULAR ELECTRICITY. In the first number, which appeared twelve months ago, its object was expressed as "to make Electricity Popular, and POPULAR ELECTRICITY a Household Word." We need only say that it is fulfilling its purpose in a manner that is fully acknowledged by a number of central station authorities who have themselves proved its value, and are pleased to testify their appreciation of this economical electricity business getter.

As said, there has been a general rousing of central station men to the advantages of publicity and the necessity of commercial endeavour. The result has been the institution of a large number of schemes and devices towards that end; some of these are good, others are of no value. Now is the time to establish such work on a definite provedly successful scale; the past year with its numerous variety of efforts has served to show what lines should be followed for the best results.

In all cases wherever commercial work is to be done, there are two watch-words to be always borne in mind—Expenditure and Persistence. Many of the schemes are doomed from the outset on the score of expense. High-salaried officials, and canvassers engaged solely for the purpose of extending a central station's list of consumers, and high-class art publications in particular, are far too expensive in proportion to the business done. Whatever scheme is adopted, first and foremost there must be printed literature circulating widely and constantly over the area of supply.

People must be provided with well printed, illustrated, readable books always at hand to inform them and prevent their forgetting what electricity is doing; that it is sheer extravagance for them to retain gas and oil and steam; that they are shareholders and virtually the controllers of the borough electricity system, and so on. This is the very foundation of commercial work in electricity supply, and it cannot be accomplished in any other way than by the constant circulation of the right kind of publication. To prepare such publications is the work of experts; articles must be to the understanding and interest of the people, and they must be convincing. Moreover, this campaign of informing the public cannot be effective if undertaken intermittently; spasmodic efforts are useless. The circulation must be continuous and frequent. It is certainly best to make a big fusillade at the start, but a constant fire must be maintained; advertising in every walk of life, to be successful, must be *persistent.* For any electric supply authority to institute for itself such a wide but essential plan of advertisement would be impossible because of the expense.

There is, therefore, but one way in which the desired end can be attained—the principle of co-operation must be followed. In our editorial columns we publish some particulars of an established co-operative electricity business developing system now at work in the United States and doing immense good.

The Electrical Publicity Bureau, with POPULAR ELECTRICITY, is working on similar lines; all those interested in electricity supply systems should communicate with us and learn for themselves the remarkable success which has attended this novel organization as a result of its first year's work.

Practice versus Theory in Substation Operation.

S. W. ASHE.

OPERATING men who have had the greatest experience in the school of practice are men who seldom write for publication, who rarely present papers at the meetings of engineering societies, and who are loth to discuss papers at these meetings when they are present. As a result of this condition there seems to be a preponderance of theory in engineering literature.

With this idea in mind the writer entered the employ of one of the large electric railway companies in New York, and for two months made a close investigation of substation operation. During this period a study was made of the individuality of various operators; the effect of various combinations of apparatus upon the operation of the system as a whole; the utility of automatic apparatus; the effect of depreciation, maintenance, distribution of operators' time; and of the desire to work at the different periods of a twenty-four-hour day.

The Appreciation of Small Periods of Time.—Imagine that an overload on the line has occurred when the second hand of a watch is at sixty. Then count one, two, three, four, five seconds. If the overload relays in the substation are set for five seconds then this is the interval which is allowed for the operator to reach the middle of a switchboard, watch the banked ammeter needle for an instant to see whether it is ever coming back, and finally to pull his section switches or to adjust the fields on the rotaries so as to shift some of the load to adjoining substations to keep his station from going out of commission. During this time the brushes of the converters are sparking viciously and the converters emitting the low painful grinding sound characteristic of an overloaded machine. This illustrates the great value to an operator of a few seconds of time. It is clear, therefore, that any arrangement of switch gear which will facilitate the manipulation of switches by the operator is to be recommended.

Another illustration of the value of time: Most of us have undoubtedly started, by means of a direct-current starting box, machines of about 10h.p. Let us assume that a man experienced with small units is about to start for the first time a 1500kw. rotary converter, using a five-point starting switch, the machine starting from the direct-current side. What would be the result if he performed the operation with the large machine in the time required with the small machine, probably eight seconds? The rush of current into the 1500kw. converter would be so great as to trip out the circuit breaker on the starting bus. The inertia of the large converter is so great and the resistance of its armature circuit so small that fully twenty-five seconds should be allowed for such an operation. Here is only a difference between twenty-five seconds and eight seconds—small enough, but still of vital importance.

One great advantage with rotary converters started from the alternating-current side is the small amount of time necessary to start such machines from rest and have full load upon them. The writer remembers one instance in which a 1000kw. converter was started from rest, synchronised, and placed under full load in twenty-eight seconds. This is the minimum value that the writer has ever obtained upon test. One can readily imagine in cases of sudden overload the great value of such quick operation. With this method of starting time is saved by the absence of synchronising, as the machine builds up directly into synchronism.

Consider another case, namely, the closing of an oil switch. This operation requires about four-tenths of a second. Assume that the switch is operated from local storage batteries, and that the battery voltage has been allowed to fall too low. Assume also that a rotary is being synchronised and that the local battery switch is closed at the right time. The result might be that the oil switch would close a fraction of a second late. This would cause the converter to be connected to the circuit out of step, resulting in severe sparking.

The Effect of Inertia of Armatures.—It is a common mistake with new operators to imagine that, with converters out of step, if the oil switch (connecting the converter to the alternating-circuit side) is closed at the instant of synchronism, that no sparking will occur. Such operators close the local battery switch when the pointer of the synchronoscope is moving rapidly over the dial; and although the pointer may be over zero at the instant the oil switch closes, the converter will spark viciously. Considerable energy is required to overcome the great inertia of the converter armature, and the sparking is a direct result of this. The only proper way to synchronize a machine so started is to adjust its voltage and speed so that the pointer of the synchronoscope is moving slowly over the dial, and to close the local battery switch as the pointer is approaching zero and is a few degrees off the zero mark. As it requires four-tenths of a second for the oil switch to close it will close the circuit by the time the pointer of the synchronoscope reaches zero, showing synchronism.

Connecting a Converter to the Direct-Current Bus.—It is natural for a beginner to connect a converter which has just been synchronised to the direct-current bus when the voltage of the converter is the same as the bus, and when the total fluctuating station load has a low peak. In doing this the operator makes two mistakes. In the first place, regarding the voltage, if the converter voltage is the same as the bus voltage before tying the machine in, it is likely that the bus voltage will be slightly higher than the converter voltage when all of the switches are closed. This is due to the IR drop. The result is that the current tending to leave the converter will reverse, and the reverse current relays mounted on the positive switch will trip the machine out of circuit. Consequently the converter voltage should be about 40 volts higher than the bus voltage in order to ensure perfect operation. Regarding the second feature, namely, the load. When a converter having small self-induction in its armature circuit is connected in parallel with other converters, the load, if low, is quite likely to readjust itself so that the new machine will become overloaded. This is due to the converter "going in" having a higher power-factor than the other machines. If the field rheostats of all the converters operating are set for unity power-factor at normal load (almost full load) the power-factor will become poor when the fluctuating load is small. If the positive switch of the machine "going in" is closed when the load upon the individual converters is about two-thirds full load it will catch all of the converters at about the same power-factor, namely, unity, at which point it will be itself. The new machine will then draw a load slightly lower than the other converters. Its field rheostat can then be readjusted till it draws the same load as the other machines. This condition applies to substations of large capacity in which converters are usually operated without their compound coils.

Effect of Self-Induction of Converter Armature Circuit.—Most operators know that there is a fixed relation between the voltage of the direct-current side of a converter and the voltage of the alternating-current side. These operators do not understand how, if this fixed relation exists, it is possible to adjust the load upon the converters by regulating the field rheostat. It is true, as we know, that this fixed relation of voltages is a fact; but, nevertheless, by altering the inductive electromotive force of the converter by varying its field strength, it is possible to alter the direct-current voltage slightly, but enough to produce load regulation.

It is desirable for good running characteristics that a converter should have the smallest possible self-induction in its armature circuit. There are several ways of neutralizing the self-induction of converter armatures, one of the most successful of which is that used by the Westinghouse Company. The pole faces of the converters are slotted, and copper grids are inserted in the pole faces, in which position they are faced up. This form of pole damper is effective because it is very close to the armature surface, and furthermore, being of grid form, it impedes the passage of flux which tends to shoot across the pole face of the converter when hunting is about to occur.

Maintenance.—In considering the maintenance of a substation it is convenient to assume that all of the care bestowed upon the apparatus, excluding supervision, operating, and repairs, is restricted to the efforts of three rotary tenders each working eight hours per day, including Sundays. Their time per week as devoted to the various types of apparatus will be divided approximately as follows :

	Hours.	Per cent.
Rotary converters	93	55.36
Transformers	42	25
Starting sets	3.5	2.08
Transformer blowers	3.5	2.08
Oil switches	3	1.79
Auxiliary apparatus	21	12.50
Local storage batteries	2	1.19
Total	168	100

It may be observed from this table that 55.36 per cent. of the total time is devoted to the maintenance of the converters, whereas but 1.78 per cent. of the time is spent in testing and cleaning the oil switches. Also the starting sets where employed have but 2.08 per cent. of the total time, and the auxiliary storage batteries operating the control have but 1.19 per cent. of the total time. It is true that the transformers and the converters perform perhaps heavier service than the oil switches, blower motors, batteries, &c., but the factor of safety of the system as a whole could be increased considerably by devoting more time to this lighter apparatus.

In the larger stations where a station foreman and a janitor are employed in addition to the operators and the rotary tenders it would seem that considerably more time would be spent upon this detail work, as the duty of this apparatus is heavier, but about the same proportion of time applies, the additional time being taken up with repairs.

In order to increase the efficiency of railway systems as a whole it has become the practice of some of the large companies to select a corps of experienced men whose time is devoted exclusively to inspection of instruments, oil switches, and feeders. At regular intervals these men go the rounds of all of the substations, inspecting their particular apparatus. One body of men devotes its time exclusively to instruments, another to oil switches, and still another body to the inspection of feeders. By this system the factor of safety of operation is considerably increased. In addition to this special inspection, a considerable part of the time of the station foreman is devoted to this purpose.

Working at the Different Periods of a Day.—Planning the duties to be performed by the station help at the different periods of the twenty-four-hour day, it would be natural for the theorist to apportion the work equally. Such a division, however, would not meet entirely with success. Assume, for instance, that the time is divided as follows : 9 a.m. to 5 p.m., 5 p.m. to 1 a.m., 1 a.m. to 9 a.m. Some companies make the division 8 a.m. to 4 p.m., 4 p.m. to 12 m., 12 m. to 8 a.m. Taking the first case, consider the man whose watch is from 9 a.m. to 5 p.m. This watch is equivalent to a regular eight-hour day, and there is every inclination when on this watch to perform one's duties willingly. Consider the second watch from 5 p.m. to 1 a.m. The operator retires about 2 a.m. and sleeps till about 10 a.m. He arises and uses his day with the feeling that he has been staying out rather late ; and then, at 5 in the afternoon, when other men are leaving work, his working day begins. He works till midnight. A man on this watch has small desire for work and possesses a feeling of lassitude most of the time. Furthermore, his time for recreation is practically worthless. Few operators like this watch. Consider the third watch, from 1 a.m. to 9 a.m. This watch is termed the "graveyard watch." It is very hard to arise at 12 o'clock at night and get ready for work so as to be there at 1 a.m. But operators do not seem to mind this watch, as the load on the station is usually light until about half-past five, at which time travel increases. Moreover, operators feel that they have the whole day at their disposal for pleasure should they so desire it. Some operators prefer this watch to others.

Summing up, the heaviest work should be done on the day watch and the lightest work on the five to one watch. On the latter watch the machines might be blown out with compressed air, but such work as sandstoning commutators, sandpapering brushes, and repairing should be done on the day watch. On the morning watch dusting, polishing, and cleaning up the station generally should occur.—*Elec. Rev. N. Y.*

LIGHTING and Heating

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Lighting and Heating.

Prospects in Electric Lighting and Heating.

With the beginning of 1907 the view of electricity as a lighting and heating agent is more directed to the future—to the great promise of radical changes in general practice and a consequent abnormal development in these always progressive phases of applied electricity.

This year would appear as destined to see the universal adoption of metallic filament lamps. The tantalum lamp has, during the past few months, become known at its true worth as a decided economical advance. The use of osmium and tungsten and their alloys for filaments is now established beyond doubt as the line to follow in incandescent lamp manufacture. There are already "Osram" and "Osmi" lamps available, but they are as yet scarce; we had occasion to enquire for some of these lately and ascertained that the dealers were quite unable to cope with the demand. However that is a trouble that can easily be righted, and before very long we shall doubtless see the new lamps installed everywhere, and our old favourite since the beginning of electric lighting—the carbon filament lamp—finally ousted as a standard illuminant. We have already published a deal of information about the new metallic filament lamps and need not enter into details here. With their introduction electric lighting will be able to compete with any form of gas lighting so far as cost per candle-power-hour is concerned, and at the same time all the other well-known advantages and economies of electric lighting will be maintained. Tests of these lamps show such remarkable economies as an average current consumption of 1 watt per candle power, and this high economy maintained over a life of at least 1000 hours; the tests show further that their average life is considerably above 1000 hours.

In arc lighting the tendency is all towards flame-type lamps for general illumination. Many excellent lamps operating on this principle are now available. Still another form of arc lighting, which bids fair to become very popular, is the miniature arc for indoor illumination. These small long-burning lamps are proving very successful, and, of course, they are highly economical.

So far as electric heating is concerned the prospects are of the brightest: never before has there been such a great demand for electric cooking and domestic appliances. The public supply authorities have learnt the wisdom of making a special effort in the development of this long-neglected branch of applied electricity. Special low prices are now the rule for the current supply to these devices: pamphlets and circulars, exhibitions, demonstrations, and lectures have spread abroad the possibilities of electricity in this direction. These have set the ball rolling. With the encouragement of brisk business the manufacturers are incited to greater effort—competition is very keen, and the result is that the electric stove or kettle of to-day is a far superior and more economical device than it was only a year or two ago. There are available a thousand and one designs to suit all tastes and pockets, and all are of definite ratings so far as current consumptions and reliability are concerned.

Incandescent Lamp Comparisons.

In the course of a paper recently read before the Karlsruhe Electrical Society, the author presented some particulars as to the comparative cost of lighting with different electric incandescent lamps. If k is the cost of 1 watt-hour in pfennigs (8 pfennigs = about one penny), s the watts consumed per hefner-candle, p the first cost of the lamp in pfennigs, d the useful life in hours, and n the candle-power of the lamp in hefner-candles, then the total cost, y, per hefner candle-hour is $y = sk + (p \div dn)$. The following figures are given for different types of lamps:

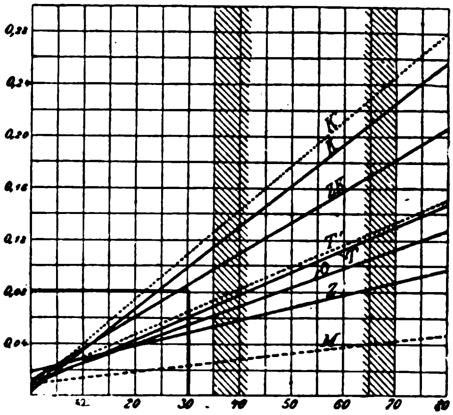


FIG. 1. TOTAL COST OF LIGHTING.

	Symbol in diagrams.	n watts.	(c.p.)	d (hours)	p (pfg.)	s (watts per c.p.)	First cost per c.p. hour.
1*a* Carbon filament	K	25	80	750	50	3.2	0.0027
1*b* Carbon filament	K'	25	87.5	750	50	3.5	0.0027
2*a* Tantalum lamp	T	25	44	1,500	250	1.76	0.0067
2*b* Tantalum lamp	T'	25	44	1,500	400	1.76	0.016
3 Osmium lamp	O	25	37.5	2,000	400	1.5	0.008
4 Zirconium-carbon lamp	ZK	25	61	300	75	2.44	0.010
5 Zirconium lamp	Z	25	25	800	350	1.0	0.0175
6 Metallic filament lamp (Kuzel) ..	M	25	12.5	1,000	200	0.5	0.008

The figures for lamps 1 to 3 are the results of exact tests. The figures for lamps 4 and 5 are those claimed by the manufacturers. Lamp 6 is that of Kuzel, and the figures represent what the inventor hopes to accomplish.

In Fig. 1 the total cost of lighting with the different types of lamps is plotted graphically for different prices of electrical energy. The abscissæ represent the price of the kw.-hour in pfennigs, while the ordinates are the cost of the hefner candle-hour in pfennigs. It will be seen that the carbon lamp is more expensive than all other lamps except for extremely low rates for electrical energy which never occur in practice. The point where two lines cross gives the rate for which the two lamps are equally expensive. To show these points more clearly, the left-hand corner of the diagram Fig. 1 is reproduced on a larger scale in Fig. 2. Of the different factors, s, p, d, and n, the one which has the greatest influence on the position of the curves is s, *i.e.*, the watts per c.p.

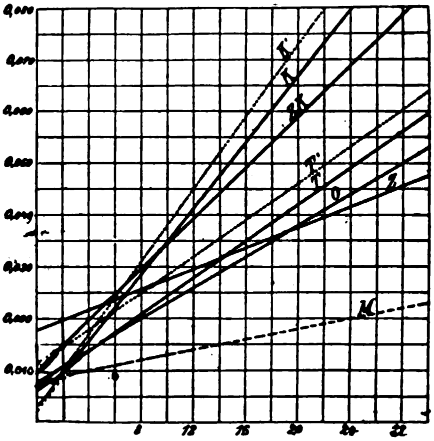


FIG. 2. ENLARGEMENT OF SECTION OF FIG. 1.

Central Station Managers can largely increase the number of customers on their mains by communicating with the ELECTRICAL PUBLICITY BUREAU, 4, Southampton Row, London, W.C.

*Domestic Electric Heating.**

J. I. AYER.

FOR popularising the use of electricity for domestic heating and cooking purposes the author favours the introduction of electric heating devices by personal presentation, and recommends for the use of canvassers the lists of meter readers' routes and a card catalogue divided into sections for a record. Circulars, or a typewritten letter with circulars, should be sent out a few days in advance announcing a proposed call and its object. Articles should be left on trial after fully explaining their operation, and they should be accompanied with complete printed instruction. The length of trial depends upons the device. The customer should be called upon at the expiration of the trial period, instead of being communicated with by letter. It is good practice to invite prospective customers to a practical demonstration of electric heating, such as cooking a light lunch to be served to them.

The electric iron is an ideal article for the introduction of electric heating. For laundry use they are required from three to five hours per week, costing 5d. per week for the longer period with electricity at 2d. per unit. Using the flat iron as an opening wedge it is well to follow with circulars describing such articles as water cups which will furnish a pint of boiling water in seven or eight minutes in the smaller size, or a quart in a larger size in ten minutes. Either will supply enough for a cup of tea in three or four minutes, and for shaving in less time. These articles are invaluable in the sickroom, and for use in hundreds of ways. Improvements in these devices prevent their burning out or overheating in the event of boiling dry. This result is obtained by the circuit being broken automatically if the temperature rises a few degrees above the boiling point. An electric heating pad can always be placed in a home where there is use for a hot water bottle. Its superior merit is immediately appreciated on the briefest investigation. Aside from its usefulness in illness, it is much used by the aged as a foot-warmer.

The nursery milk warmer performs its work by electricity more uniformly and perfectly than is possible with any other method and in shorter time. An important feature is that the time required to heat the milk throughout to an even temperature is less than three minutes, making the period so short after the demand is made that peace is certain. Its operation and sanitary character produce universal commendation from physicians. These devices are furnished with a socket plug arranged to receive the lamp which it displaces in the fixture, that is lighted when current is on the milk warmer.

Electric curling iron heaters are welcomed in many homes. For light cooking and the dining-room there are many useful articles. The chafing dish has many accomplishments to its credit. It can perform nearly all the operations of cooking required in homes, but of course in some cases not on the same scale as to quantity, and only one operation at a time, yet its possibilities are limitless when electrically heated. It can bake, boil, fry, stew and toast; is under perfect control, and always performs the same under like conditions, because its heat supply is a known quantity. It is a simple matter to cook and serve a good breakfast for three, of a cooked cereal, eggs poached, boiled, fried or scrambled, with toast, in thirty minutes with a chafing dish at the cost of 250 watt-hours, and coffee can be made for 100 watt-hours more.

Chafing dishes, tea kettles and coffee urns can be had with heaters attached or separate in a variety of grades and designs, and there is no other method so safe, simple or cheap for performing similar service in the dining-room. The cost for energy for performing any single operation with any of these devices is more often one half-penny, or less than more, and never exceeds twopence.

Disc heaters, or stoves with utensils, such as saucepans, tea kettles, coffee pots, cereal cookers, vegetable boilers and the like enable the housewife with, say, two stoves and two or three utensils to do all the necessary cooking for light meals, in the dining-room if she pleases, within the limits of cost previously mentioned. Stoves or disc heaters should always be supplied with utensils made for them of suitable proportions and with perfectly flat bottoms.

For general cooking there are available individual cooking devices in all sizes required for the largest household; also ovens, plate warmers, broilers, griddles, frying kettles, &c. Demands for general cooking will be to fill the place now occupied by gas stoves, which, except in apartment houses, are largely summer workers. Considering for the present those cases where the principal use is in summer, it is customary when using gas stoves to operate the coal range one or two days each week for supplying hot water for washing and the bath, and of course cooking at the same time, and this reduces in many cases the demand for service to perhaps six days each week.

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*Abstract of paper read before the National Electric Light Association U.S.A.).

Experience has shown from a great variety of sources that the number of watt-hours per meal per person may safely be taken at 300 or 900 per day per person. If, however, we allow one kw.-hour per person, we have 30kw.-hours for a month, which at a 2d. rate is 5s.

By careful comparison it has been determined that in cooking an equivalent cost for gas at 3s. 6d. per 1000 is 2d. per kw.-hour. Gas, however, occupied a broad field at a much higher price than coal, due to its advantages, and electric methods make it possible to secure equal results because of the many advantages possessed by the newer method over the old.

For heating the general water supply a kitchen boiler of the usual type is used, varying in capacity from ten to thirty gallons, and supplied preferably with a heater contained in the boiler of a maximum of 2000 watts, which may be reduced to 1000 or 500 watts by a controlling switch; such a boiler should be jacketed with ordinary pipe covering, and with care is not necessarily an expensive luxury. A ten gallon boiler can be heated to 150° F. with approximately 2½kw.-hours, which will answer a very considerable demand throughout the day from a jacketed boiler of that capacity.

For bath water, heaters are supplied to place in the tub, and if of 2000-watt capacity are frequently satisfactory to those who understand in advance that it requires 2000 watts for an hour to raise 20 gallons of water through 40° F.

Radiators for occasional use in bedrooms for short periods are practical and useful, but should have a capacity of not less than 1000 or 1200 watts to be at all effective, except in the case of small rooms, and should be larger for large rooms. For heating the bathroom many radiators are sold which to be effective quickly should have 2000 watts capacity. Of this size, if turned on for fifteen or twenty minutes, they fully accomplish their purpose and are not expensive to the owner.

The instantaneous hot water heater to be practical requires that current supply of 3000 watts and more be available. While for small quantities the cost of operation is not excessive, the service demand is undesirable, and it is expensive to install; and as small water heaters are so much more simple and easy to supply, they meet the demand for small requirements. The field of water-heating radiators in any community, with rare exceptions, is very limited, yet the sale of these devices reaches a very considerable sum annually, and is daily increasing.

The service for a family kitchen for the average family for cooking should have capacity of about 3000 watts, and if a kitchen boiler, bath water heater, or bathroom radiator is to be included, a double-throw switch can be installed in the kitchen or other convenient place so connected as to throw off the boiler, radiator or bath circuit when the cooking circuit is required, and to avoid the necessity of extra large service capacity which would otherwise be necessary. This also suggests a method of limiting the hours for cooking service to a period when lights are not required, but it has objections although it is practical.

The cost for heating one gallon of water to different temperatures at different rates is given in the accompanying table, the initial temperature being 60° F. and the efficiency of apparatus 85 per cent.

	Watts used for				Cost in pence with current at	
Total Temperature	5m.	10m.	20m.	1 hr.	1.5d.	2 5d.
110°	1296	648	324	108	.36	.27
150°	2976	1488	744	248	.37	.62
175°	3744	1872	936	312	.47	.78
200°	4608	2304	1152	384	.57	.96
212°	4992	2496	1148	416	.62	1.04

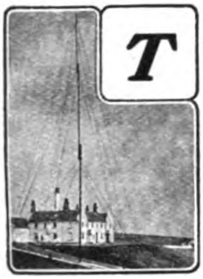
The policy to pursue is to personally press the sale of small household devices constantly, without complicating the situation by trying to interest customers with the larger problems, until from experience with the smaller they have become prepared for further ventures.

POPULAR ELECTRICITY is becoming the recognized Publicity Organ for the Central Station Man. It brings business!

TELEGRAPHY & TELEPHONY

For titles of all important Telegraph and Telephone articles of the month, see World's Electrical Literature Section.

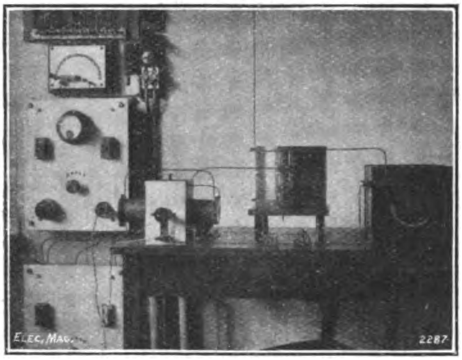
The New Telegraphy.



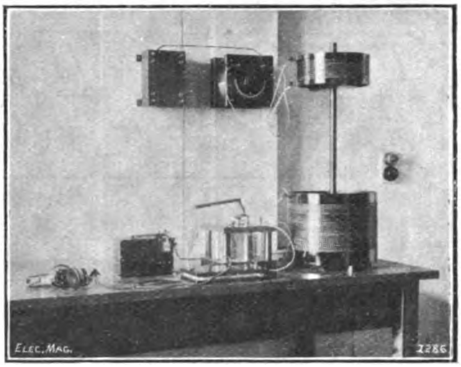
The close of the past year saw the publication of a most important discovery which promises to revolutionize methods of telegraphy and telephony. The Poulsen wireless system was described in full in our last number. We are now able to give our readers portraits of the already famous inventor, Mr. Valdemar Poulsen, and of his colleague, Mr. P. O. Pedersen; also views of the finished apparatus as in practical and successful operation, maintaining communication between this country and Denmark. The principle employed is that of using undamped electrical oscillations for the transmission of signals, the result being extreme economy of power over the longest distances, and a very high degree of tuning or selectivity. The source of the oscillating current is a simple electric arc adapted and arranged in circuit as for producing the well-known phenomenon of the "singing" arc, The transmission and reception is, of course,

Mr. Valdemar Poulsen

Mr. P. O. Pedersen.



Poulsen Transmitting Apparatus.

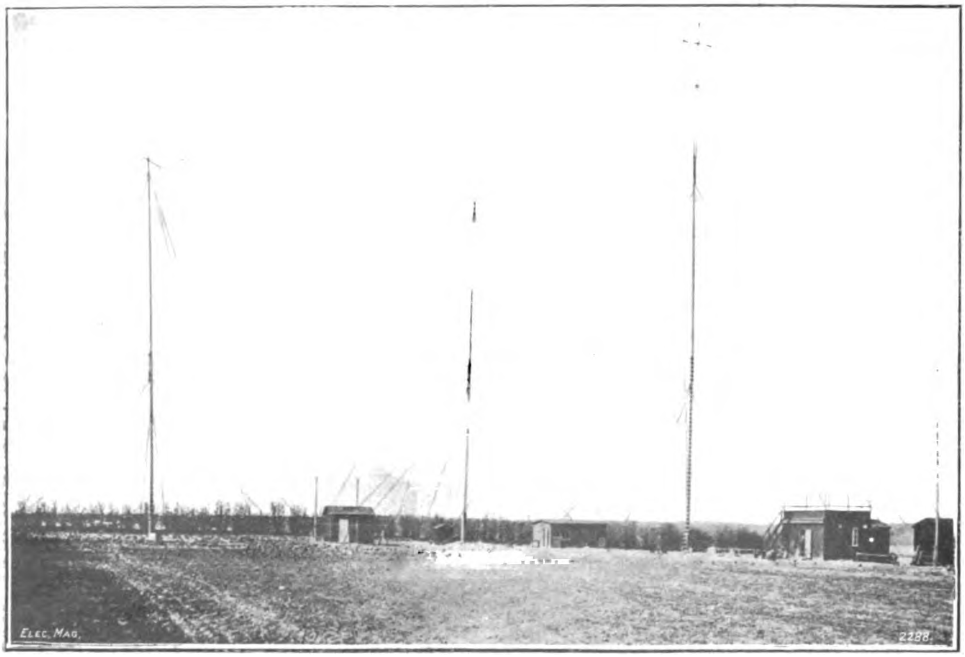


Poulsen Receiving Apparatus.

a matter of resonance, and the degree of fineness in tuning obtained between one instrument and another without mutual interference occurring is in practice represented by one per cent. difference in the respective wave-lengths of their circuits. The communicating stations at Copenhagen and North Shields are about 350 miles apart, and a perfect interchange of messages is kept up continuously with a power of about 1kw. and masts about 100ft. high.

It is said that the inventor is now perfecting a similar system of wireless telephony, and we can expect to hear of something very startling and of the greatest value in this branch of electricity in the near future.

For the use of the interesting illustrations herewith we are indebted to The Amalgamated Radio-Telegraph Company, Ltd., of London, who have the control of the Poulsen inventions.



General View of the Poulsen Wireless Station at Lyngby, near Copenhagen, which is in Regular Communication with England.

Telephone Relays.

J. TROWBRIDGE.

When we consider that the telegraphic relay merely responds to one throb, so to speak, one inarticulate impulse, while a telephonic relay must reproduce the whole range of the human voice, we begin to realise the demand that the invention of such a relay must make upon both scientific knowledge of sound and of electricity and magnetism; and above all, upon mechanical skill.

The earlier inventors who attacked the problem naturally thought of the simple device of applying a microphonic contact immediately to the vibrating diaphragm of a telephone, hoping to repeat the almost infinitesimal vibrations of this diaphragm, and to give them an increase of energy by a local battery. The application of the microphonic contact loads the diaphragm at its most sensitive point and thus prevents the vibrations which one seeks to repeat; moreover, the vibrations of the diaphragm are too minute to cause a sufficient agitation of the microphonic contact.

The next step in the mind of the inventor was to endeavour to increase the vibration of the centre of the telephonic diaphragm by a lever. This arrangement was found to be inoperative, for the short arm of the lever exercised a prejudicial pressure on the vibrating diaphragm; moreover, the fundamental vibrations of the lever were superposed on the vibrations of the diaphragm, thus completely confusing speech.

It was perhaps natural to suppose that a number of microphonic contacts placed on a number of telephonic diaphragms, the telephones being arranged one after the other in tandem, might gather, so to speak, the slight vibrations of each and throw them in a united volume upon the relay line. This chorus arrangement, however, is also a failure; for the united speech is confused; much as if a number of persons singing the same note, some through the nose, and others imperfectly, should undertake to transmit the note through a number of telephones. The imperfection of each microphonic contact disturbs the final result.

It must be remembered that the telephone is after all an imperfect instrument and its wonderful adaptiveness is greatly aided by the human brain, which catches at the connection of thought. This can be seen if individual words are transmitted without context. Moreover the amount of energy utilised in the telephone is extremely small; most of the energy of the currents which actuate it and transmit speech is dissipated in heat. Some observers think that less than one per cent. of the energy of such currents is transformed into sound waves. We see, therefore, that the problem of the telephone relay calls for all our electrical and mechanical aids to preserve and to transmit this small percentage.

Since mechanical enlargement of the vibration of the telephonic diaphragm by levers is out of the question, the next most promising step seemed to be the bringing in, so to speak, of electromagnetic energy, and it has been proposed to cause the telephonic currents on the circuit to be relayed, to react by induction on a neighbouring circuit, at several points. This method gets rid of mechanical pressure on the vibrating diaphragm of the telephone, and substitutes an electrical pressure without any visible connection between the circuits. This method also is ineffective. It has, however, a certain analogy in another and more successful attempt to utilize an invisible and intangible magnetic effect without bringing a mechanical pressure on the telephonic diaphragm; this method consists in causing the telephonic currents to disturb a piece of iron, a balanced magnet, or a suspended coil in a strong magnetic field.

The principle of this method is that of the siphon recorder, the invention of Lord Kelvin, which is used on ocean cables. Since the current on the cable is very feeble, and cannot work ordinary telegraphic instruments, some method must be used to magnify or to record the signals. The method adopted by Lord Kelvin was that of a delicately suspended coil so placed between the poles of a powerful magnet that when the feeble currents passed through this coil it oscillated; for the feeble currents animated the coil, making it an electromagnet, the poles of which sought the poles of the powerful stationary magnet. Thus a very feeble electrical current could be detected by the powerful magnetic influence to which it was subjected. Here we have a mechanical movement, the movement of a vibrating system, produced without the intermediation of visible connecting parts.

It has, therefore, occurred to many minds that by the use of this principle of magnifying the vibration of moving parts by the reaction between the feeble currents in such parts and the environment about these parts, one should be able to strengthen or repeat such vibrations. The mechanical difficulties, however, are very great if one endeavours to apply this principle to the problem of the telephonic relay. A delicate suspension such as is used in the siphon recorder or the D'Arsonval galvanometer is out of the question; and a rigid suspension prevents the turning movement, the seeking of the poles of the powerful magnet by the little coil which conveys the feeble currents. A certain measure of success, however, can be obtained by careful adjustments in a laboratory; but the utilization of the turning movement of a little coil in a magnetic field has not yet proved of commercial use in telephony.

We are apparently brought back to some modification of the simple principle of the disturbance of a powerful magnetic field by the effect of feeble currents circulating around coils placed in such fields. Suppose, for instance, tnat we have a hollow electromagnet with another electromagnet suspended above it, the iron core of the suspended magnet forming a part of the core of the stationary more powerful electromagnet. The system can evidently be balanced, in various ways; for instance, the suspended magnetic core can be maintained in a definite position by connection with a telephone diaphragm; and when a feeble current circulates through the coil of such a suspended electromagnet its position with respect to the stationary coil is changed. Instead of the diaphragm of a telephone, it is evident that a diaphragm connected to a microphone contact can be employed. This idea can be found in the efforts of many inventors to construct a relay. Professor Dolbear has described a telephone which works upon this principle; a non-magnetic diaphragm placed close to the pole of a permanent magnet carries a little electromagnet which is balanced under the influence of the elasticity of the diaphragm and the magnetism of the permanent magnet. When the voice causes the diaphragm to vibrate, the movements of the little electromagnet disturb the magnetic field, producing feeble currents of induction in the little moving coil which transmit speech to a similar piece of apparatus. If this similar receiving apparatus of Professor Dolbear had been employed to modify a microphonic contact, it would have been the precursor of many subsequent inventions.

Instead, therefore, of the turning or torsional effect relied upon to actuate Lord Kelvin's siphon recorder, we have efforts to utilize the to-and-fro thrust of a vibrating core of an electromagnet whose position in a powerful field is modified by the strength of the feeble telephonic currents which circulate around the core of such a magnet.

At first sight it would seem that the inertia of the suspended electromagnet, or that of its core or plunger, if the coil of the electromagnet is fixed, would be so great that the motion of the microphonic contacts would be seriously impeded. It is true that the weight of the vibrating parts in this form of relay must be small, and there must not be any subsidiary vibrations of the moving parts which might be superposed upon the vibrations due to the telephonic currents. It is evident that such subsidiary vibrations can arise if the moving parts are long and of considerable size. With a loaded microphonic contact we can have feeble effects or roaring sounds, as if the membrane of the ear were loaded by an obstruction.

The magnetic part of a relay embodying the above ideas can be suitably constructed so as to perform to a commercial degree of perfection; the principal imperfection of the relay arises from the microphonic part. Among such imperfections the most notable one is the roaring or "growling" of the microphone when a strong battery is used to get the greatest degree of sensitiveness. This noise, which arises in great part from crepitations produced by heat, can completely overpower telephonic transmission of speech. The crepitation is greatly enhanced by the direct connection of the plunger or moving electromagnetic coil with the microphonic contact; for the movements in the magnetic field and the crepitations in the microphone get into a swing together, mutually aiding each other. This mutual action is one of the greatest barriers to the perfection of a telephonic relay in which a close connection exists between the parts moving in the magnetic field and the microphonic contacts. To overcome this defect would be a great service to the art of telephony.

It is thought by some that this crepitation noise is analogous to that of the singing electric arc. It can be started in any transmitter either by too strong a current, or by a suitable reaction between the vibratory motions in the transmitter and the current in the telephone circuit of which the microphone is a part. For instance, the roaring can be started by holding a telephone connected with the circuit directly in front of the transmitter.

With the view of accomplishing two results, I have constructed the following form of telephonic relay. The results to be attained are as follows: First, the prevention of the reaction of the magnetic parts on the crepitation of the microphone to obviate the excessive roaring or "growling"; secondly, to provide means for a separate adjustment of the magnetic moving parts and the transmitter. This separate adjustment is evidently highly desirable; for the part moving in the magnetic field may be in a suitable position for the greatest sensitiveness, while the microphonic contact has not a suitable contact pressure; and any disturbance of adjustment of one of these parts of the apparatus disturbs the other. In accomplishing these results, the fact came out with great clearness that the separation of the microphonic contact by means of an air chamber from the magnetically moving parts, a separation claimed by many inventors, is inoperative unless there is a better sound-conducting medium between the microphonic contact and the vibrating part in the magnetic field than the layer of air. In fact, the layer of separating air is incapable of transmitting the feeble vibrations of a telephone diaphragm sufficiently for relaying; while a suitable solid sound-transmitting support to the microphone in contact with the edges of a diaphragm actuated by the movements in the magnetic field transmits such vibrations very efficiently. This is an exemplification of the fact that a person partially deaf can hear if the vibrations are conveyed to the ear by contact with the support of the ear.

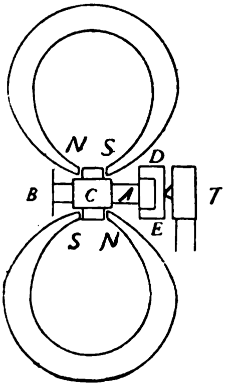


Fig. 1.

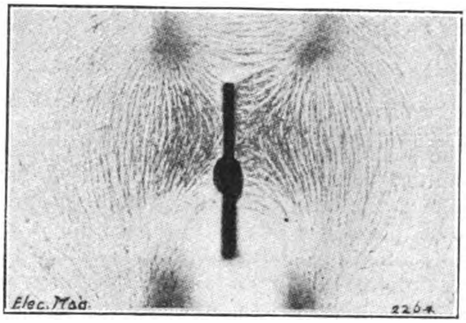


Fig. 2.

Considering thus the principle involved in the construction of a practicable telephonic relay, I have invented the relay described herewith; a relay in which the barrier of undesirable "growling or roaring" is obviated; and a relay which permits of the desirable separate adjustment of magnetic parts and microphonic parts.

The relay consists of a small coil with a laminated iron core, which is balanced by two small diaphragms in a balanced magnetic field: the telephonic currents to be repeated or relayed enter the little coil and disturb the magnetic balance in the magnetic field.

In Fig. 1. *NS* (diagrammatic) represent the poles of the magnetic field, *C* the moving coil actuated by the telephonic currents to be relayed, *A* and *B* the supporting diaphragms, *DE* the sound communicating support of the microphonic contacts or transmitter. This can be a heavy disc: in some experiments I have used a brass disc one-half an inch thick, and have relayed loud and articulate speech. The main features of this relay are these: the magnetic field acts both in the direction towards *B* as well as towards *A*. Fig. 2 shows by the lines of magnetic filings the character of this magnetic field.

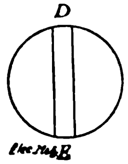


Fig. 3.

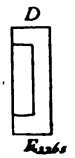


Fig. 4.

The second important principle is the freedom of the central portion of the diaphragm *A* from the pressure of the transmitter *T*. The third point is the transmission of the vibrations of this diaphragm *A* by means of the sound-transmitting support of the transmitter, to the transmitter *T*. As I have already said, the air enclosed in the chamber *DE* plays a very small part in the transmission of the vibrations of the diaphragm *A*. A proof of this important fact is as follows:

Fig. 3 represents a front view of the support *DE* of the transmitter, which in this case consisted merely of a metallic bar. Fig. 4 is a side view of this case. Here the air space between the transmitter and the diaphragm *A* is not enclosed, being open on both sides of the bar, which is connected at its edges with the diaphragm *A*. The transmission of speech in this case is loud, while if the connections at *D* and *E* with the diaphragm are removed, and the bar upon which the transmitter rests, in the same position parallel to the diaphragm *A*, a very feeble sound is transmitted through the intervening air.

One can, therefore, adjust the transmitter without bringing a pressure upon the most sensitive portion of the diaphragm *A*, its centre, and without disturbing the adjustment of the moving coil *C*. The relay is very sensitive; it is loud and the articulation good. Moreover, it is free from the objectionable growling or enhancing effect of the crepitation of the microphonic contacts on the vibrations of the magnetic portion of the relay.

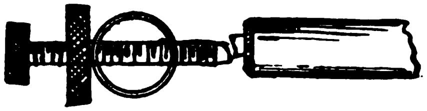
The engineering problems connected with loading telephone lines are most interesting, and when completely solved may obviate the use of relays, and telephonic engineering may go through a phase analogous to that of the Morse telegraph, in which the telegraphic relay is subordinate in importance to good conducting lines. Nevertheless, we have not reached this point yet, and the cost of a relay is practically nothing in comparison with the enormous expense of a loaded line. The device described in this article seems to me to be an important solution of the problem of the telephonic relay.—*Telephony.*

Care of Platinum Points.

L. CASPER.

The importance of perfect alignment of contact points of instruments in telegraph service cannot be overestimated if a high working efficiency is desired. It is not only extremely advantageous to have points strike squarely in order to make good connection and utilize all the cross-section of the same, but it will be the means of mitigating if not entirely avoiding sparking due to irregular wear which occurs when points are poorly aligned.

The accompanying figure illustrates what will logically occur with constant pounding on only a portion of the surface of the points. Only the portion that is in contact will wear away and form indentations, which will result in excessive sparking unless the points are frequently filed down to a level, which, by the way, is a very undesirable thing to do when the price of platinum has reached an almost prohibitive stage within the last few months.



THE EFFECT OF NON-ALIGNMENT OF PLATINUM POINTS.

A frequent cause for points being out of line is often due to poor or worn-out trunnion bearings of the armature or binding screws. If the screws in such cases are tightened so as to hold the points in alignment, the armature will bind; so the lesser of two evils is often adopted by permitting the points to come out of line by loosening up the binding screws sufficient for free movement. Such instruments are mere makeshifts and had better be consigned at once for repairs.

In view of the high price of platinum, it might be suggested, instead of frequent filing, to occasionally burnish the points with a smooth piece of steel. The writer found this an excellent medium to clean points with very little wear, only using a very fine Swiss file at long intervals.—*Tel. Age.*

The ELECTRICAL MAGAZINE offers you Remarkable Privileges for 1907 if you become a Regular Subscriber Now. Write us.

Every aspect of the design and manufacture of electrical apparatus is dealt with in this section month by month, and Engineers connected with large manufacturing concerns are especially invited to contribute.

60,000-Volt Series Transformers.

W. H. THOMPSON.

THE series transformer shown in Fig. 1, including the terminal, is 8ft. high and its capacity is 40 watts. The ratio is 200 amperes primary and 5 amperes secondary.

The diagram, Fig. 2, shows the method of connecting to the high voltage line. A small spark gap is connected between the primary terminals to act as a protection to the primary line in case line surges should occur, which might injure the internal insulation of the primary coil. Under normal full-load conditions the drop between the primary terminals is very small, and hence there is no necessity for much insulation. They therefore are brought out through the same insulating tube and bushing. As shown the high tension bushing is of extraordinary length. This is necessary in order to provide the surface between the terminals and the cast iron cover of the case. The bushing extends down inside the case about the same distance as outside. The transformers are oil cooled and hold about 52 gallons of oil; they are insulated to withstand a breakdown test of 120,000 volts for one minute. The transformer itself, without oil, weighs 275 pounds.

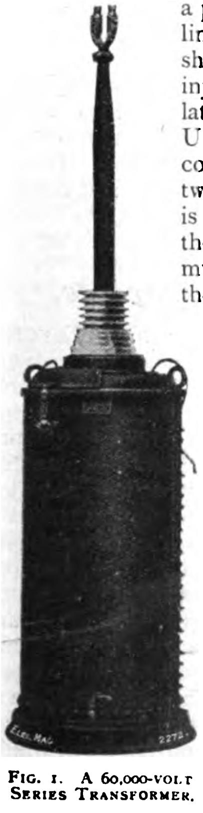


FIG. 1. A 60,000-VOLT SERIES TRANSFORMER.

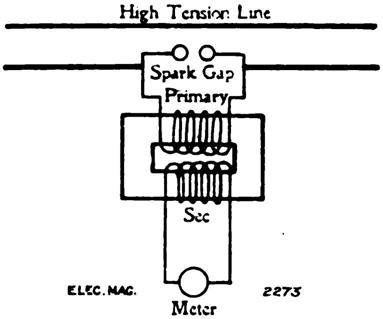


FIG 2.

In some cases it is desirable to operate both meters and circuit-breaker from this type of transformer. In such cases a transformer with separate secondaries is provided, as shown in Fig. 3. This is done because the variable load of the circuit breaker affects the ratio of the transformer if there is only one magnetic circuit. Transformers of this type are similar in appearance to the one shown in Fig. 1, excepting that the case is taller and four secondary leads are brought out.—*The Electric Journal.*

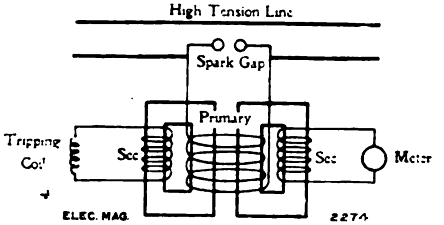


FIG. 3.

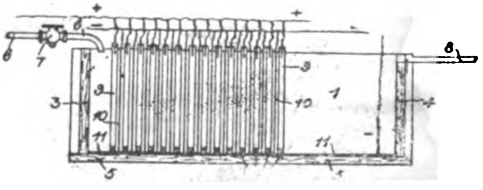
ELECTRO-CHEMISTRY, Electro-Physics and ELECTRO-METALLURGY

Titles to all important articles on the subjects covered by this section will be found in the World's Electrical Literature Section.

Electrolytic Extraction of Gold.

THE following is an abstract of some particulars of a recent American patent published in *Electro-Chemical and Metallurgical Industry*; the patent, by J. Snodgrass, is an interesting one as coming from Johannesburg and as showing the tendency towards the electrolytic method of gold separation in the Transvaal.

The precipitation box is shown in the illustration. The solution enters the box through 7 and leaves it through 8; 9 are the anodes, and 10 the cathodes. The latter rest on a sheet 11 of iron on the bottom, which is in electrical connection with all the cathodes. The special feature of the process is the construction of the porous electrodes. The cathodes 10 consist of very fine iron-wire gauze in an iron frame. A screening of 10,000 meshes per square inch is satisfactory. Inside of the gauze a woven fabric of fine texture may be used, which is rendered a conductor by a coating of plumbago. The conductivity may be increased by dipping the cloth into a solution of a lead salt and then into a solution of an alkaline carbonate or sulphate. By this means a deposit of carbonate or sulphate of lead is formed on the fibres of the cloth, and after the cathodes have been placed in position in the box the first passage of the current reduces the lead to the metallic state, and so increases the conductivity. A combination of cloth and wire gauze may be used, woven fabrics being placed on both sides of the wire gauze network. The anodes are constructed with a wooden frame with pieces of porous cloth of very open texture, such as flax scrim. The compartments thus formed are filled with an insoluble conductor in the form of powder or small lumps of gas carbon or coke. The solution flows slowly through the box, and when passing through the porous cathodes the precious metals are deposited on the same. The iron plate 11 at the bottom prevents the redissolution of any particles of gold which may become detached from the cathodes 10 and come in contact with the plate 11.



ELECTROLYTIC GOLD EXTRACTOR.

Artificial Soft Graphite.

IN the November number of THE ELECTRICAL MAGAZINE it was noted that Edward G. Acheson, the inventor of carborundum, had discovered a means of producing soft graphite in the electric furnace. Quoting from the patent specification the manufacturing process consists of "heating in an electric furnace a charge comprising essentially carbonaceous material, such as mineral coal, coke, petroleum-coke and the like, and one or more carbide-forming material, the latter being in excess of the proportion of natural ash contained in any coal, but in less than the theoretical proportion required for production of a carbide, that is, the carbon is present in greater proportion than is required to reduce the metallic compound or carbide-forming material and to combine with the base thereof with formation of a carbide."

The following specific example of the process is given. An electric furnace, having a length of 18ft. between terminal electrodes, was provided with a starting core consisting of a graphite rod ⅞in. in diameter. The active zone, 18 inches in diameter, surrounding this core was filled with a mixture of carbonaceous material and carbide-forming oxide. The materials used in this instance were anthracite coal, ground to pass through a ½in. mesh, mixed with sand, in the proportion of 65 per cent. coal and 35 per cent. sand, the ash contained in the coal being calculated as a part of the sand content of the mixture. Completely surrounding the active zone above referred to was disposed a mixture of anthracite coal and sand in the proportion of 1 part coal to 2 parts of sand, this mixture having a much higher resistance than that in the active zone, and serving as an effective heat retainer. The furnace being charged in this manner the electric current was turned on, and at the beginning registered 79 volts and 75kw. After two hours the register showed 203 volts and 200kw., and after 9½ hours showed 135 volts and 800kw. The register after a run of 15 hours still showed 800kw., while the volts had dropped to 70, as the result of decreased internal resistance due to the formation of graphite. When cold the furnace was opened and 962 pounds of soft, unctuous and non-coalescing graphite were removed from the active zone.

Silica is preferred by the inventor as carbide-forming material, for the reason that oxides which form fluid carbides are more or less difficult of treatment in an electric furnace.

Alundum—Its Manufacture and Characteristics.

Before the invention of the electric furnace, artificial abrasives suitable for grinding wheels were unknown. Wheel manufacturers necessarily depended upon natural products—chiefly corundum and emery. As emery occurs in considerable quantities in various parts of the world, it came to be recognised and used as the chief raw material for grinding wheels and other products employed in grinding metals. On this account the modern grinding wheel made of any abrasive is popularly known as the "emery wheel."

The Norton Company has during the past few years been operating an electric furnace plant at Niagara Falls, in which has been developed and brought out a superior abrasive, known as alundum. Eleven electric furnaces have been installed, each capable of turning out three tons of alundum every twenty-four hours.

The process of making alundum, as described recently in *Machinery*, consists in taking the purest amorphous oxide of aluminium found in nature, known as the mineral bauxite, and purifying and melting it in the electric furnace into a large homogeneous bath or fluid mass. Upon cooling, this molten fluid solidifies and crystallizes in solid masses of alundum of great purity and absolute uniformity throughout.

Bauxite was originally found at Baux, France, from which it derives its name, but purer forms are now obtainable in the United States. The best quality only is used in the manufacture of alundum, and in its preparation practically all impurities are removed.

The bauxite is heated in large preliminary heating furnaces to drive off the combined water, and is then melted directly in electric furnaces of special design. The temperature at which the furnace charge melts into one homogeneous mass, is above the limit at which temperatures are measured by any means known to science, and is variously estimated between 6000° and 7000° F. The operation of these furnaces and the composition of the molten baths are under the control of the furnace operative. Exact quality and uniformity, which is so important in steel manufacture, is fully as important in the manufacture of alundum. The highest grades of steel are now being made in electric furnaces similar in design to the alundum furnace, because impurities can be removed at the high temperatures obtained by the electric arc, and the quality of the molten bath uniformly maintained. In the alundum furnace both the purity and uniformity of the alundum is assured. Each step in the process is under the close supervision of expert chemists.

The large masses of molten bauxite are allowed to cool and crystallize in great ingots of purified crystalline alundum. Beautiful crystals are found in the centre of these masses, showing nearly all the variety of colours found in the ruby and sapphire, of which alundum is the commercial, artificial product. The rarer colours of light pink, blue and purple found in the rarer oriental gems, are sometimes noticed in small crystals. The ingots of alundum are broken up into small pieces by means of powerful crushers. It is then passed through series of rolls to reduce it to the various sizes of grain, which are finally separated by passing over sieves of different mesh to prepare it for manufacture into grinding wheels, rubbing and sharpening stones, &c.

The solid massive alundum, while resembling the purest natural corundum in chemical composition, has the remarkable quality of being considerably harder than the natural product. This is due to the perfectly fluid condition in which the mass is melted, the control of its composition, the rate and method of its cooling and crystallization by which it receives its temper, the absence of water of combination (which almost invariably exists in natural corundum), and the pure and even state in which the fluid mass crystallizes.

The introduction of alundum in the field of grinding has been remarkably successful and rapid. The requisites sought for and attained in this abrasive are extreme hardness and sharpness, combined with uniformity and proper temper.

To have sharpness in order to obtain the most satisfactory results—so far as rapid and continued cutting is concerned—a peculiar quality is necessary. There must be a fracture which will give a number of sharp-cutting points. This is obtained in alundum to better advantage than in any other abrasive material.

In the matter of hardness the recognized standard is the diamond, which is No. 10 in the scale of hardness; nothing that man has yet discovered or made equals the diamond in hardness. The term "hardness" is therefore a comparative term, the hardness of a mineral being ascertained by its ability to scratch another mineral of a known degree of hardness, or to be scratched by such a mineral.

Pure crystalline corundum, represented by the best sapphire or ruby, has always been the standard of No. 9 in the scale of hardness. This is readily scratched by alundum; in fact, alundum powder is used for cutting and drilling rubies and sapphires for watch jewels, &c.

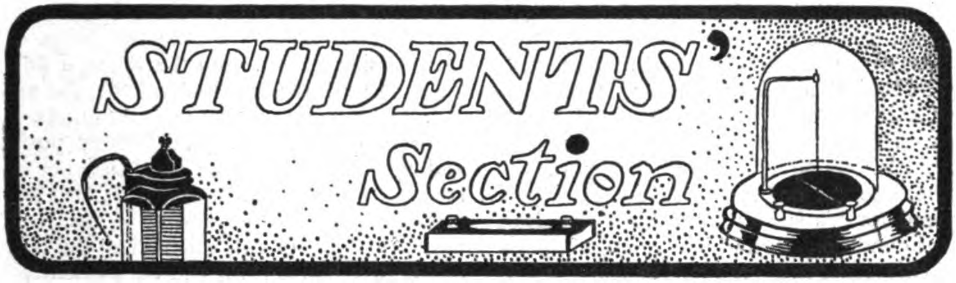
After numerous careful tests, comparing alundum grains with other abrasive grains, including the diamond, alundum is found to exceed 9½ in the scale of hardness where the diamond is 10.

By "temper" is meant its strength of grain and the character of its fracture under grinding pressure. An alundum grain is remarkably tough, and will stand more crushing pressure before breaking than any other abrasive grain, but when it does break down it breaks with a sharp, crisp fracture, giving a fresh keen-cutting edge. This is a most important quality in an abrasive.

The purity and uniformity of alundum surpasses that of any other abrasive. Purity, besides resulting in greater hardness and better temper, is necessary in the bonding of the grain into wheels, in order to secure accurate and uniform results, and uniformity is necessary to secure constant efficiency and accuracy of grade and temper in a wheel, so that wheels can be accurately duplicated at any time, and maintain their standard of work.

Uniformity is one of the most important requisites. The ability to duplicate a grinding wheel is essential to efficient results from its use. In grinding wheels the abrasive grain of given size is bonded together to produce a certain grade or temper for a certain kind of work. This means that the bond, which holds the grains together, must be harder or softer according to the particular work required of the wheel. Different grades are required for different materials to be ground; cast iron, steel, brass, glass, bone, leather, wood, and other substances, demand wheels of special grade, which must be duplicated to make the grinding operation continuously efficient. It is for this most important reason that great stress is placed on evenness in quality of the abrasive itself. Grades cannot be duplicated accurately without having a known and dependable factor in the uniformity of the material composing the wheel: and this important requisite is to the highest degree found in alundum.

Alundum and the process of making it were awarded the Grand Prize at the St. Louis Exposition. The individuals responsible for its invention and development were honoured with diplomas and medals for their work and enterprise in the discovery and perfection of a fast cutting and uniform grinding medium which is already invaluable in engineering manufacture.



STUDENTS' Section

Students should refer to the World's Electrical Literature Section for classified list of articles of special interest to them.

A Growing Opportunity.

WHEN the young man is casting about for a profitable and congenial business to which to devote himself for life, if his inclinations lead him toward the realm of engineering, he cannot but feel somewhat disheartened by the state of this profession at the present time. There are scores of engineering schools in the country attended by thousands of students, great numbers of whom are graduated each year. It is truly said that there is a great demand for these graduates on the part of engineering firms in various lines, but this demand is for young men who are willing to work for long hours at small wages for the sake of gaining "practical experience." The upward steps from these positions are difficult and the openings leading to the ascent are few. Besides, the salaries obtained by even the best engineers are not commensurate, so at least it seems to the young man, with the time and study and money which he has expended on his education. Especially is this so when compared with the harvest reaped by the financial managers and the members of the selling organization in great industrial undertakings.

It is not safe, however, to consider this as a permanent condition. While this field is an attractive one at present, the increasing growth of the idea of combination and community of interest is bound to lessen competition more and more as time goes on, and competition is the only factor which makes it possible for the selling agent to receive the abnormal rewards which he now enjoys. Considered from a purely abstract standpoint, indeed, this condition does not seem to be a stable one. The salesman's business is an economic waste, so far as the country at large is concerned, in the sense that he does not add to the wealth of the country an amount corresponding to the value he receives for closing his large contracts. He merely diverts business from one channel to another.

Competition in the future will largely be waged in the workshop and factory instead of in the city offices. This condition is one that must, in the nature of things, call increasingly for men skilled in the art of production at a minimum cost, who can get the most possible out of men and machines without unduly distressing either. This is the most attractive opening for the intelligent, energetic young man of to-day. The steps that he should take to perfect himself in the art of management cannot be definitely laid down. Each one will have to search them out for himself. A technical education will be no hindrance and should be of great help, not only from the greater knowledge of scientific principles which it gives, but also in the training given in expressing one's ideas in handwriting and in speech and in the broadening influence of contact with numbers of other men with similar aims in life. But a technical training is not absolutely necessary. The works manager has to make large use of the brains of others when it comes to solving engineering problems, and will give up his own time mostly to questions of organization and administration. This can best be learned by actual practice in the art. The steps to be followed are the old-fashioned ones from the ranks of the workmen up through the petty foremanships to the higher positions of responsibility. He must consider, however, unlike the ordinary foreman, that he is studying and striving to master a definite and complicated science—

a science which is in the main a region whose prominences are unmapped and whose routes of travel are undetermined and unmarked.

The typical manager of the past, like the old-fashioned engineer, attained his eminence through unusual and fortuitous natural endowment. The efficient manager of the future, like the engineer of the present, will depend for his success on accurate analysis of the conditions with which he is confronted, and carefully considered and executed plans for accomplishing the results he desires. This is the field which to-day presents the most inviting opportunities in the mechanical world. As to how it shall be entered, each one must determine for himself. There are few places where one can serve a definite apprenticeship in the art, and no college has yet added the study of the science to its curriculum.—*Machinery.*

◆

A Peculiar Static Trouble.

R. P. JACKSON.

A FEW cases have been noticed recently where static disturbances having no connection with lightning have caused trouble and damage. A typical instance was that of two 6600-volt generators delivering power to a transmission line through delta-connected transformers having a ratio of 6600 to 66,000. It was found that when a ground occurred on one leg of the transmission line static disturbances and breakdown of the insulation occurred on the generators. The probable key to the cause of this action is furnished by an investigation of the static conditions prevailing in the circuit.

The two windings of a transformer act as the two plates of a condenser. This will be readily appreciated if it is remembered that when a single terminal of a transformer is connected to a high-tension circuit, the other terminal being idle, there appears a difference of potential between the second coil of the transformer and the earth. This is due to the fact that one winding of the transformer by being connected to the high-tension circuit has its potential rapidly changed from positive to negative. Consequently, the other coil of the transformer, which acts as the second plate of the condenser, has induced upon it a charge alternately positive and negative, which may give a spark to ground.

If the one coil of a transformer has its two ends connected to the two wires of a high-tension circuit, then the average potential of the primary winding will be the mean of the potential of its two terminals. If these two terminals are alternately positive and negative, and these potentials are symmetrical with respect to the earth, and if the positive value of the one is equal to the negative value of the other, then the potential of the coil is zero, and consequently no charge appears upon the second coil, provided the windings are symmetrically related. If, however, one terminal of the circuit be grounded, then the average potential of the primary is equal to half the voltage of the circuit, and a charge will appear upon the secondary winding. If the secondary winding of the transformer is connected to an insulated circuit, such, for example, as the armature of a generator, then this whole circuit will be subject to an alternating static charge, provided one terminal of the high-tension winding is grounded. The potential difference between this circuit and the ground will depend upon the numerical relation of the capacity between the high-tension and the low-tension windings of the transformer to the capacity between the insulated circuit, including the high-tension windings, the generator armature and the earth.

In the case of a three-phase circuit the same general principles apply with some modifications. Three delta-connected transformers well insulated from ground may be represented by a triangle rotating about its centre as shown in Fig 1. The horizontal line represents zero or ground potential. Thus, part of the transformer windings will be seen to be charged to a positive potential and part to a negative. The numerical value of the potential at any point is proportional to the distance of that point from the neutral line at that particular instant. As charges are proportional to the product of static capacity and potential it will be found by multiplying each element of the windings by its distance from the neutral line and adding the products that the negative and positive charges are always equal. As the phases of the three transformers change the triangle rotates, but the charges remain fixed in relation to the neutral line, with the result that the two charges actually follow each other around the delta in a manner similar to the north and south poles of an induction motor due to its rotating magnetic

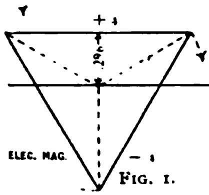


FIG. 1.

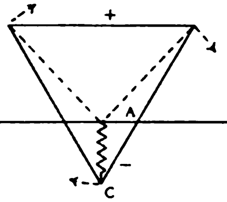


FIG. 2.

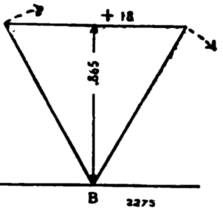


FIG. 3.

field. As in this case the two charges are always equal no current has to be supplied from ground.

This is not the case when a point in the delta becomes partially grounded as, for example, through a very high resistance. The condition is now shown by Fig. 2. The triangle still rotates, but the centre of rotation is displaced towards the point in the windings at which the partial ground exists. The positive and negative charges on the windings are no longer equal, however, as at times there is more positive and a little later in the cycle the negative charge is the greater. The result is that an alternating charging current has to be supplied through the partially grounded point.

If one leg of the transmission line becomes solidly grounded, the condition shown in Fig. 3 exists in which the triangle is rotating around one corner. In this case all the windings become alternately positive and negative in relation to the ground, and if each element of the triangle is multiplied by its average distance from the neutral line and the products added as before the charge will be found to be 4.5 times as great as each of the charges on an ungrounded system. All of this current has to be supplied through the grounded point.

Fig. 4 shows how this condition may cause trouble. The high tension windings of the delta receive alternately positive and negative charges, and with the low tension windings form a condenser. The generator forms, likewise, a condenser between its windings and the iron. These two condensers are in series between the high-tension windings and the ground. Two condensers in series divide their potential strains inversely as their capacities, and as the capacity of the generator windings to the iron is generally large the corresponding strain on the insulation may not be great enough to puncture it. In the case mentioned, however, one generator was feeding a bank of large transformers, and the capacity of the high and low tension windings to each other was comparable to that of the generator windings to ground. Of the 66,000 volts across the two condensers somewhere near half could be across that formed by the generator windings and its iron. Any voltage near 30,000 volts is obviously a destructive potential for apparatus insulated for 6000 volts, and the result would be a puncture.

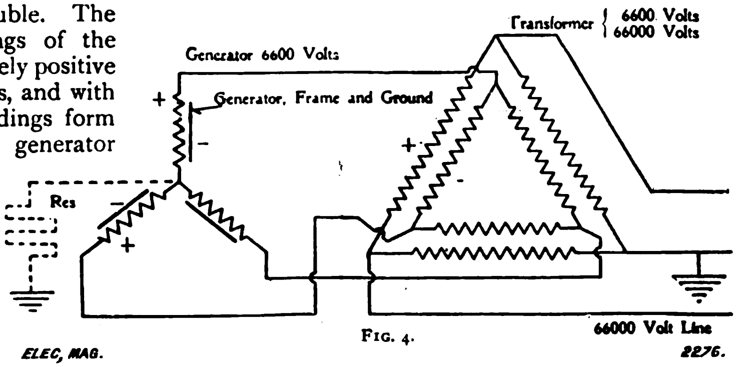


FIG. 4.

A step-down transformer on a transmission line will be subject to strains to its iron and case, but if oil insulated it is usually better able to withstand them than a generator. The obvious remedy is to ground some point, preferably the neutral of the low-tension windings as indicated by the dotted lines in Fig. 4, so that the charging current can be supplied directly. It is not necessary that this ground should be a complete one, but only that a sufficiently low resistance be inserted between some point of the windings and the ground to permit the charging current to flow without a large rise of potential.

When obscure cases of insulation breakdowns occur it is well to look for possible causes analogous to the one here described.
—*The Electric Journal.*

MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

Manufacturers' Facts, 1906-1907.

WITH a view to ascertaining exactly what general progress had been made during the past year in electrical manufacture and the more closely allied branches of engineering, we wrote a large number of the leading firms inviting them to express their views as to business done and the prospects for the coming year. The nature of our enquiry was varied, and called for particulars as to new specialities and modification of designs; the particular class of machine or goods which showed the greatest improvement in the way of demand; the general state of trade during the year; the tendency of prices; the more noteworthy contracts; the effect of foreign competition; special features of home competition; the most prominent factors influencing trade in 1906; and the outlook for 1907.

It will be seen that for our friends to accede to our weighty request meant a considerable call upon their time, and that just at the close of the year, when time in business is particularly precious. We are pleased to be able to record a large number of replies, and desire to tender our sincere thanks to those enterprising firms who so kindly entered into the spirit of the matter.

The following particulars are based on the information sent us by the respective firms. They form a unique collection of facts and are well worthy of our readers' closest attention and study.

Johnson & Phillips, Ltd.

The designers in each of the departments of this progressive firm have been very busy throughout practically the whole of 1906 re-designing and bringing thoroughly up to date the various plant manufactured; especially in the electric light and power departments has this been the case.

During the past year the d.c. and a.c. motors, alternators, dynamos and transformers have been re-designed. These new designs have increased their efficiencies, whilst by the aid of new plant which has been installed in the shops the Company has been able to decrease the cost of manufacture.

In the instrument department they have perfected the new penny-in-the-slot prepayment electricity meters and also an automatic time switch, which is believed to be the only absolutely automatic time switch made, orders for which have already been booked.

Early in the present year they hope to be ready to supply a new shilling-in-the-slot pre-payment watt-hour meter, for which there appears to be a growing demand.

In the switchgear department has been designed a patent slow-movement starter to comply with the latest Home Office rules. A new line of switches and starters to compete with the low-priced articles now being placed on the market has also been introduced.

High-tension and extra-high-tension switchgear has received an especially large share of attention, and this department now manufactures a thoroughly up-to-date oil switch, and also extra-high-tension enclosed fuses.

In the arc lamp department the new departures consist chiefly of various new flame arc lamps, and more particularly the adoption of a vertical carbon type, giving a very high candle-power. In this connection it may be noted that existing lamps can be readily adapted for use with these carbons.

In the cable department new specialities consist of Patersons' vulcanised bitumen cable, which has proved a complete success, and also the Patersons' fireproof cables.

It is very difficult to point to any particular product of this firm's manufacture as having shown a greater improvement than others in the past year, as the output from each department has shown a most gratifying increase; in many cases night and day shifts have been kept going throughout the year.

As a consequence Messrs. Johnson & Phillips consider that the past year has been an exceptionally good one for business in general, and one of the reasons which they put forward for the large amount of electrical business which has been handled is that proprietors and managers of industrial concerns throughout the country have at last come to the conclusion that by the aid of electricity in their factories they are able to considerably decrease the cost of the manufacture of their products.

The tendency has been for the price of raw materials to steadily advance throughout the year, and naturally this has had an effect on the prices of most finished products, especially those in which a large proportion of copper is employed in construction.

Among the many large contracts handled during 1906 are the following: All cables, arc lamps and boxes for the complete electrification of the Portsmouth Dockyard. All the underground cables and boxes for the electrification of Whale Island. The complete equipment of the Fort William sub-station, including the supply and erection of a motor generator, automatic booster, battery, and switchboard to control the complete equipment for the Belfast Corporation. Contact and lowering gear for all the arc lamps throughout the Borough of Bermondsey. The complete electrification of the sheds and yards at Neasden for the Metropolitan Railway Company, including the supply and erection of three-phase underground cables, switchboards, three-phase motors for driving all the machine tools, and bare overhead lines for arc lighting. The supply and erection of the complete plant for electrification of the historical town of Stratford-on-Avon; this includes about five miles of underground cables, also the erection of generating station and the necessary suction gas plant with gas engines, dynamos, booster balancer, switchboard, and battery. Feeder cables, distribution boards, and underground boxes, all laid and erected complete at the Small Arms Factory, Enfield Lock.

With the revival of the tin mining industry in Cornwall has come the demand for electrical gear for use in the mines, and Messrs. Johnson & Phillips secured an order for complete generating plant, pumps, and cables for one of the mines belonging to the South-West Cornwall Mines, Ltd. A contract of a special nature was that for supplying and erecting electrically driven pumps for draining the low-lying area of Southsea for the Portsmouth Corporation; included in this contract are two 150b.h.p. motors, two large switchboards, special recording apparatus, and cables.

Many other contracts have been secured during the year, but they are too numerous to be mentioned in detail here. They include plant and cables for numerous Corporations, such as Dublin, Handsworth, Clacton-on-Sea, Grimsby, &c.; arc lamps for Japan, India, Hankow, Hong-Kong, Melbourne, Rio Janeiro, &c.

Cables for the Admiralty, War Office, India Office, General Post Office, and several foreign Governments, also for home and colonial railways; the machinery orders include a 350kw. alternator, 1100 volts, to the Low Moor Iron Company, and some 200k.v.a. alternators for India, and, to the Mauritius Lighting Corporation, alternator, Pelton wheel, switchboard, transmission line, piping, &c.

For a continental cable works the firm has supplied some single-phase oil-cooled transformers from 5000 to 50,000 volts; they have also supplied a number of transformers ranging in voltage from 10,000 to 20,000.

A speciality made by this firm is a line of cable drums with slip rings for making contact whilst cable is being wound and unwound for use with sinking pumps. They also build cable-making machinery and have received some very substantial orders for this work, amongst which is included the complete equipment of a large cable-making factory in France.

Messrs. Johnson & Phillips have the rights to manufacture (under licence) motor vehicles on the Auto-Mixe principle, and this business is in course of development.

Referring to foreign competition, it is the firm's opinion that this has not increased in severity, probably owing to the very flourishing condition of the home trade in Germany and the United States. They believe that this year promises to be a very good one as far as the electrical industry is concerned, they having a large number of very satisfactory orders in hand which will keep the works going for some months. Moreover, the number of enquiries received daily is more than double the number they received at the commencement of 1906. The above report is exceptionally good reading; it is one song of prosperity; and it is not surprising to learn that this enterprising British company is now engaged in considerably extending their works in order to keep pace with the increased demand for their productions.

Phoenix Dynamo Manufacturing Company, Ltd.

This well-known company reports that they have made no modification in their standard machines during the year. It is only eighteen months or so ago since they introduced an entirely new series of both direct-current and alternating machines, securing for that purpose the services of two of the most prominent designers.

In the direct-current machines the use of auxiliary poles (in the development of the modern application of which, and in showing how they were to be made a commercial success, this company were the pioneers), coupled with the thorough ventilation of the machines—these being the subject of important patents held by this company—have had the effect of placing them in a very satisfactory position to meet competition, in that for a given output the amount of active material is considerably less in their machines than in those of other makers.

New specialities introduced during the past year include the "Phœnix" electric bench grinding machines and also internal grinding machines for large work.

If there is a more improved demand for any particular products, it is possibly variable-speed machines that have shown the greater increase and also the "Phœnix" electric sensitive drill has experienced a much greater sale.

The past year commenced badly, possibly owing to the General Election, but since June the Phœnix Company find that there has been a most marked increase in trade, and that the last six months of the year show an increase of 50 per cent. above their best previous period.

The prices of all raw materials have very considerably advanced, copper having nearly doubled in about a year. Still in face of this it is exceedingly difficult, with the keen competition existing, to get any increase in selling prices, and it is only those makers who, by new designs and the consequent reduction in materials by the use thereof, can have been able to come through the year without heavy losses.

Among important contracts completed by this company during the past year and in hand at its close are the following:—Motor generators for Sunderland; 600kw. set at Gloucester; three 165kw. generators for the Great Western Railway Works at Swindon; four variable-speed (55b.h.p., 175 to 700r.p.m., 460 volts) motors for Johannesburg Electricity Works; balancer booster set for Barrow; 200kw. set for Nuneaton; complete plant for electrical department of Cape Town University. In hand at present are a large contract for sub-station machinery for Birmingham Corporation, totalling some 2000kw., there being twenty-eight machines; a 220kw. motor generator (11,000 volts three-phase) for Kent Electric Power Company; motor generator set for Cleckheaton, &c.

The Phœnix Company have a curious opinion as to foreign competition in electrical machinery. They do not believe it exists at present, and that the prices ruling here do not permit of much "dumping."

As to the prospects of the New Year the Phœnix Company think that the demand generally will be even better than that of the last six months, and confidently look forward to 1907 being a better "all round" year.

The London Electrical Fittings Company, Ltd.,

advise that the tendency in new designs of electric light fittings during the past year has been towards the Georgian and Chippendale form, though they are pleased to note that there is still a steady claim on the Adam ornament, a most pleasing form of decoration when not carried to excess. One thing to be grateful for is the almost total annihilation of the so-called "New Art" work, which was all very well when treated by artists of the best schools, but unfortunately the designs lent themselves to being badly copied and cheaply turned out, until one came to having the most horrible contortions in metal work, all duly styled "New Art;" it is hoped that this state of things cannot occur with the revival of the old English forms.

Of new devices introduced during the past year, particular mention is to be made of a ball fitting to take the Ritelite lamp, and others of a similar class which are meeting with much success; also an adaptable dining-room corona, which may easily and quickly be converted into a ceiling light.

This company is of opinion that in a general way trade in this branch of business has been bad, but that they have had nothing to complain about, having maintained a steady increase and keeping prices well up. Speaking of the competition with small accessories, it is found that this is so great and prices are so cut that unless a firm specializes in high-quality goods of their own make, they are not worth the handling.

This firm finds German competition very heavy in accessories for shipping orders; there is a difficulty in finding a cure for it unless Colonial houses are persuaded to specify British goods. The general rule with shippers appears to be to accept the lowest price regardless of quality, resulting in inferior goods of German manufacture getting in where British goods should.

The London Electrical Fittings Company is strongly against electricity-supply bodies being allowed to trade direct, and they believe that more general good can be done by financially assisting small contractors, and thus promoting electricity supply in those districts neglected by the larger firms.

The Improved Electric Supplies, Ltd.

Modifications have been made during the past year in all this company's chief designs of street lighting gear, automatic switches, and other electrical apparatus, where such were needed, to bring them up to modern requirements. Several novelties were introduced, including a new automatic switch, a new type of radiator, new systems of shop-window lighting, and a new mechanical intermittent flasher, capable of adjustment to six, twelve, or twenty-four lamps, at a nominal cost of from 10s. 6d. upwards in the case of the six lamps, besides various new bracket designs and switch designs for street lighting purposes, together with a complete range of automatic time switches.

There has been no particular class in which the demand has been improved more than its fellows, and, although the past year was the best this firm ever had so far as business is concerned, generally speaking the profits were very low and business was more from outside sources than from our own home trade. The tendency of prices has been upwards in everything.

Amongst many town installations undertaken by the I.E.S., Ltd., during the year 1906 are those of Johannesburg, Mauritius, Mussoorie, Ebbw Vale (the latter comprises forty miles of street lighting), Stepney, and others.

With reference to competition the opinion is expressed that the reduction in profits is due to the insane cutting shown by English firms and not by foreign competition, which is so evident as to need no explanation to one versed in the electrical trade generally. Over and over again innumerable instances may be found of manufacturers quoting on a rising market at falling prices, which in many instances cannot possibly show more than 10 per cent. on the bare cost price of the material and labour. The reason why the electrical trade generally is not flourishing is that profit is given away needlessly—that is to say, where it is perfectly possible to obtain better prices manufacturers and suppliers seem to go out of their way to make the purchaser a present of the material at the lowest possible price, inconsistent with profit, having regard to the increase in establishment expenses attendant everywhere at the present time.

The Improved Electric Supplies, Ltd., have not found in any case that the manufacturing work of public electric supply bodies, or hire-purchase systems, affect the contractor or the trade generally. In this respect it is to be remarked that in many towns where the supply authorities (municipal) do their own wiring, more rigid rules with regard to the question of credit have to be made, inasmuch as the contractor has to cut lower than the Corporation price to get the work, and the Corporation, not being amenable to the imperative necessity of making profits in the same respect as the contractor, as a rule underestimates its costs.

The prominent features which strike this firm with regard to 1906 were the abnormal advances in the price of metal, the depreciation of selling prices, and the increase in export trade. With regard to the prospects of 1907, it is evident that prices of materials have now reached such a limit that prices of the manufactured article will still advance, and consequently stock orders will not be placed perhaps as freely as they might be in other circumstances. Generally speaking, there would appear to be urgent necessity for manufacturers and suppliers to adopt more common-sense methods of doing their business on lines which would enable them to show better profits, and failing this a combination of some kind amongst suppliers to regulate prices.

Cryselco, Ltd.

The speciality of this well-known firm of incandescent lamp makers which had the greatest run last year was the "Perfect" lamp, a spherical type for use in connection with a reflector, producing the result that given the light was required in one direction it was obtained with this lamp at an efficiency of 1.3 watts per candle power. The most marked increase in demand has been for high voltage electric glow lamps. The past year's trade was good, the reason being the improvement in the efficiency of the electric glow lamps manufactured. The tendency of prices has been towards considerable advance in raw material, and decreased price obtained for finished products.

The most important contracts of Cryselco, Ltd., include a three years' contract with the War Office and contracts with the Great Western, Midland, Great Northern, and the Bombay, Baroda, and Central India Railways.

Foreign competition is not keenly felt excepting in the indirect way that electric glow lamps are imported into this country without any mark, and then stamped with an English name and sold as English lamps. Home competition is characterized by the excessive cutting of prices to a level that does not show a fair profit to the manufacturer.

Cryselco, Ltd., consider that so far as electric glow lamps are concerned, the prominent feature of 1906 has been the drawing up of the standard specification for British electric glow lamps by the National Standards Committee, which will be greatly to the advantage of manufacturers in this country, provided some steps are taken to see that the specification is complied with, that is, the institution of some central organization who should be the only recognized authority to carry out tests on lamps, and pass or reject them as complying or not complying with the specification; and that the prospects of business for 1907 are good, but the prospect of price is very bad.

A. Reyrolle & Co., Ltd.

This company has not made many important modifications in designs; there has been a slight but noteworthy improvement in the details of their motor starters. Of new specialities introduced are distributing boxes of the ironclad and fireproof type. It was found that the tendency in 1906 was to increase the demand for ironclad apparatus, and also for compactness in motor switchgear. To meet this last Messrs. Reyrolle prepared one or two well-constructed complete panels, which contain all that is required in the d.c. motor circuit.

Here again it was found that last year was an excellent year for business, the demand having more than doubled. This is attributed mainly to the fact that the apparatus dealt in has become more widely known.

The business done includes two or three very large contracts for switchboards, but the main trade is made up of the sale of parts of switchboards and accessories. Among the contracts for accessories may be mentioned the Manchester Corporation, Birkenhead Corporation, West Hartlepool Corporation, the Newcastle-upon-Tyne Electric Supply Company, Ltd., and the County of Durham Electric Power Distribution Company, all for motor starters. The accessories business, so far as they are aware, is not seriously handicapped by foreign competition, clients seeming to prefer to purchase in this country and to use articles which they know are well and substantially made.

Messrs. Reyrolle consider that this year is likely to be better from a business point of view than last, but are afraid there will be a continuance in the advance in price of raw material, and consequently the prices of manufactured products are also likely to advance.

The Armorduct Manufacturing Company, Ltd.

Two new specialities were introduced by this company during the past year:— "Little Hustler" variable-speed drills, and "Blaze" flame arc lamps. The demand for "Armorduct" conduit and "Armorduct" wires and cables improved very considerably during the year, so much so that during the last few months there was some difficulty in doing justice to the orders received.

Some of the large "Armorduct" installations during the year have been: The Ritz Hotel, Hicks' Theatre, Plaistow car sheds, Sunderland municipal buildings, some fifteen cotton mills in Lancashire, four car sheds for the L.C.C., the Cardiff Asylum, the Southfield Road Schools, Acton, and many hundreds of installations of minor importance.

Foreign competition has not been felt to any extent. The foreign competition which exists does not, in this company's opinion, call for legislative remedies. They believe a sounder means exists in healthy activity on the part of British manufacturers, greater adaptability and adoption of the decimal system for weights, measures, and currency.

The company has also decided opinions as to the unfairness of home competition, which has been carried to excess in the various materials they manufacture and sell.

Archibald Smith & Stevens,

The well-known lift and hoist manufacturers have not made any radical modifications, but have introduced a very large number of improvements in detail in the direction of preventing wear and tear. Whilst they have not introduced any definitely new specialities they have doubled the range of sizes of those already in use.

They report that there has been very little change in the volume of business, and although general reports indicate an increase, the building trades generally only feel the benefit very late, and the contracts for lifts, &c., are usually the last in any building. The tendency of prices of raw material was found to be upwards, while the prices of their finished manufactures are stationary.

The following is a list of some of the most noteworthy contracts secured by Messrs. A. Smith & Stevens during the past year:—

Complete electric lift plant for the *Morning Post* new offices; three electric passenger and one electric goods for Messrs. Nathan's Wellington office, New Zealand; a large number of lifts for India; Navy Victualling Stores, Darling Island, Sydney; electric passenger lifts for Mr. J. Boot, of Nottingham, for Edgware Road, Croydon, Bold Street, Liverpool, &c., &c.

Also electric lift installations for Birmingham, Newcastle, Edinburgh, Dunfermline, Cardiff, Belfast, Liverpool, and most of the large towns in England, Ireland, and Scotland.

Machines for such well-known names as Ryland Brothers, Ltd; Humber, Ltd.; Rudge-Whitworth, Ltd.; Great Northern Railway Company; Hotel Metropole, Dublin; St. Luke's Hospital, London; Shanghai Land Investment Company; Bath Club, Piccadilly; London Stereoscopic and Photographic Company; an extensive contract for the Langham Hotel, Regent Street; Daimler Motor Company; Somerset House; His Majesty's Foreign Office; Houses of Parliament; Weights and Measures Office; Guildhall; Adelaide Hospital, Dublin; Harrogate Infirmary; London and Lancashire Fire Insurance Company, Pall Mall; Alexandra Hospital, Brighton; Times Laundry, King's Cross; London Hospital; Nurses' Home, with many others too numerous to mention.

This firm has not found foreign competition troublesome, the facts being that in spite of exaggerated claims and low prices asked for foreign-made machines, the quality is found to be so very inferior that the effect is small. Regarding home competition it is found that there is great unfairness which is felt here, particularly owing to the firm's determination to supply nothing but the very best class of machine. The product they are engaged in manufacturing is a highly technical one, difficult to bring home to the customer, and there is a kind of competition to face which appears to be a race as to who shall leave out the largest number of essentials, customers being hoodwinked by vague and high-sounding specifications.

Municipal manufacturing has only been very slightly felt, and it is not anticipated that much trouble will occur in this direction owing to the highly technical nature of the work.

Messrs. Archibald Smith & Stevens consider that the prominent feature of the past year was the keenness of competition, and in 1907 it is likely to be intensified.

The Walsall Electrical Co., Ltd.

This company devote their attention specially to switches, switchboards and instruments; they have simplified the manufacture and are able to produce reliable and efficient instruments at considerably reduced prices. The principal demand of the past year has been for switchboard work, both for private plants and large installations.

The year generally was not a very good

one, but there was a steady improvement during the last few months, and, with much work in hand, there are very good prospects for the future. Here again there is felt the advance in price of all raw materials.

The home competition in some branches of this business has been very keen, and in many cases makers must have been selling at less than cost prices for the sake of keeping their places at work. With motor and dynamo work the prices have in many cases been exceptionally low, but this is often due to uncertainty in the rating of the machines, and ambiguity in the specifications; but things are improving in this respect, as prices are getting firmer and manufacturers are refusing to sell at the very low rates which were quoted a few months ago.

The firm consider that there will be considerable business in electrical work generally during the coming year, as the advantages of electrical power for driving factories are rapidly being realised by manufacturers.

Willans & Robinson, Ltd.

The business of this world-renowned firm during 1906 has been confined principally to Willans' high-speed engines, up to and including units of 500kw.; steam turbines of the Willans-Parsons type; and surface condensing plants. The modifications introduced into the manufacture of the Willans-Parsons turbine are now fairly generally known, and consist (1) in protecting the blades by riveting them into a channel section shrouding, and (2) by mounting the blades in sections prior to assembling them on the shaft and in the casing.

Messrs. Willans and Robinson state that, due perhaps principally to the large units which are being installed, the demand for turbines during the past year has been in excess of the demand for reciprocating engines, and their works have experienced a greater influx of orders during the past year than during any previous twelve months. The following list of these turbines, either at work or under construction at the present time, gives an indication of the demand: 2 sets of 5000kw., 9 sets of 3000kw., 16 sets of 1500kw., 21 sets of 1000kw.

The principal contracts entered into during the past year are for Willans-Parsons turbines for the Corporations of Manchester, Leeds, Glasgow, Salford, Blackpool, St. Pancras, West Ham, Islington, Shoreditch, &c.

In addition to dealing with Willans' engines, steam turbines, and surface condensing plants, this company is also acting as manufacturers of the Diesel engine for the Diese Oil Engine Company, and the orders received in this direction point towards the demand that is being created for this type of prime mover.

Globe Gas Engine Company, Ltd.

Great improvements have been made in the system of lubrication and water cooling of exhaust of these engines, owing to the demand for engines to run continuously for long periods. The past year has been marked by the introduction of suction gas plants, which has also meant the re-design of all Globe engines.

The year has been a good one for business in the gas engine trade, the reason being the wonderful results in cost of running that can be got from using suction gas.

The tendency in prices of raw material and finished products has all been on the increase.

The most noteworthy contracts of the Globe Company are three sets of suction plants for the New Zealand Government; a large pumping plant with five engines and suction plants for the Fleetwood Corporation; two sets of suction plants and engines for the Borough Council of Pembroke Dock; one set for the Corporation of Worthing. The greatest demand at present is for suction gas plants and engines for abroad.

Foreign competition does not affect this trade in any way, as British manufacturers of gas and oil engines get the preference in every country except Germany. The prospects for the year 1907 are the best ever known for the gas engine trade.

Meldrum Brothers, Ltd.

All the leading products of this well-known firm, viz., "Meldrum" refuse destructors, mechanical stokers, and boiler furnaces, have been in improved demand as compared with the preceding year.

The business of the past year was fairly good; prices of raw material have advanced considerably, but finished products have not advanced proportionately. The leading contracts secured by Messrs. Meldrum are for refuse destructor and power plants for the cities of Paris, St. Etienne, Brussels (St. Gilles), Prahran (Melbourne), Pretoria, Southport, and several others. They have not found foreign competition to be on the increase, but mention that the business of 1906 has been marked by increased activity all round, and so far as they can judge, prospects for 1907 appear to indicate a continuance of these conditions.

F. Hattersley Pickard & Co.

The well-known patent ventilating fans of this Leeds company have been still further improved by having the blades in the larger sizes constructed of specially tapered steel, being twice as thick at the root as at the tip. This gives great strength across the whole width of the blades where most required, without the use of ribs or other objectionable projections, thus leaving the surfaces of the blades perfectly clear and smooth and reducing friction and power for driving to a minimum. The various sizes of these fans, fitted with alternating-current motors of either the induction or the commutator type, are now being supplied.

A recent introduction is the improved sectional air heater for working in conjunction with the fans, electric, steam, or belt-driven, which is being used for heating and ventilating workshops and also for drying various kinds of materials. A speciality is also the induced-draught apparatus for improving the draught of boiler fires, thereby reducing the working cost and improving the efficiency of steam-driven installations.

The demand for the patent fans and air heaters has steadily increased during the past year, which has been a good one for business, especially towards the latter half.

There has been a considerable increase in the prices of raw materials, but the prices obtained for finished products remain about the same. This is compensated for to some extent, however, by the increased volume of business done.

Of many important contracts during the past year may be mentioned the supplying of patent fans for the ventilation of the new building for the Leeds Y.M.C.A., the Welsh University, new police stations for the Leeds Corporation, public institutions, workhouses, &c., &c.; also combined patent fans and heaters for the heating and ventilating of factories, and the drying of various kinds of materials, besides a large number of fans, &c., supplied for industrial purposes to firms on the Continent and in the Colonies.

The company has not found the pressure of foreign competition to be on the increase in this business, but rather on the decrease, due to the discovery that cheap foreign-made goods have been found in practice by users to be badly designed and constructed, inefficient and not durable. The best way to counteract foreign competition is to supply a British-made article of superior design, construction, and efficiency than is offered by any foreign manufacturer. In home competition it is found that some firms have felt it necessary to resort to desperate cutting tactics in order to get rid of their manufactures, which they have evidently been unable to dispose of at a fair market price on merit alone.

The prominent features of business in 1906 appear to F. Hattersley Pickard & Co. to be a sure and steady increase in the demand for their manufactures, both at home and abroad; and the phenomenal rise in the prices of raw materials, and the optimistic outlook in most trades as regards business prospects for 1907. Their business brings them into close touch with almost every trade known, and they find that in the large majority of cases there is a strong impression that trade is booming, and may be expected to do so for the next two years at least.

Howard Brothers.

The latest speciality is a "Dey" time register giving the weekly time and wages sheet, which does away altogether with time books and wages books. An attachment to the machine supplies, on cards made for the purpose, the time worked on any particular job, and with duplex ribbon attachment shows the early arrivals in one coloured ink, say blue, and the late arrivals in another coloured ink, say red.

The past year was a very good one for this business, being an improvement on 1905, which was a record year.

The reasons for the improvement are that the "Dey" time registers are all the time becoming more known, and employers of labour are realising more and more the importance of having their employees' time taken by an automatic machine.

There is not much foreign competition in this line of business, and Messrs. Howard Brothers rather welcome what there is. They look at the matter from the point of view that competitors assist in educating employers of labour to the advantages attending the use of automatic registers, and are quite willing to meet competition so far as the qualities of machines are concerned as compared with any foreign ones ; regarding competition in price, they let their foreign friends take their own course, having their own prices fixed. The only remedies that this firm would suggest against foreign competitors are that they should pay duty on the manufactured goods they send into this country in the same way as we have to pay duty on the goods sent into their country.

Messrs. Howard Brothers are to be congratulated on their great prosperity, which is voiced in the expectation that 1907 will be an improvement on last year, and in the enviable satisfaction that if they never have any better years than last year and 1905, they will have no reason for complaint.

Bateman's Machine Tool Company, Ltd.

The sole product of this well-known company is modern high-speed planing machines. The recent modifications in their designs are simply towards greater weight, and the new machine of the year is a 60in. high-speed planer fitted with four tool heads and change-speed gear-box driven by electric motor. The past year is considered as good, the causes being comparative absence of international disquietude and general prosperity.

In this line of business also the trend of prices is upwards, and there is a general tendency to install better, quicker and larger tools with a view to securing more accurate repetition work, together with higher speeds. The latter is very apparent to these makers of an essentially modern high-speed tool. In support of this they mention that their sales during the year just closed were more than two and a half times as much as those of 1905 (260 per cent., to be accurate). Repeat orders alone in 1906 were equal to 72½ per cent. of the total sales in the preceding twelve months.

Hyatt Roller Bearing Company.

The leading modification made in the designs of these bearings during the past year consists in making them heavier than in the past. The new specialities introduced recently have been principally special designs for bearings to be used in motor vehicles, both heavy and light. The class of goods for which there has been the greatest demand seems to be the standard bearings for line shaft transmission work, especially in the heavier sizes.

The company is emphatic in declaring the past year to have been a most excellent one, their business having just about doubled; the attributive reasons being that manufacturers are more keen on the economical operation of plant, and that the Hyatt bearings are becoming better known. The price of raw materials has increased tremendously, and although the price of the finished product was not increased, this year some increases are obliged to be made in certain sizes.

There is no trouble with foreign competition, either in Great Britain or on the Continent, since the bearings stand practically alone, there being no other of the same construction.

Gratze Patents and Engineering Syndicate, Ltd.

The past year has seen many improvements in the motor-car accessories which are a speciality with this company, and their apparatus in general is far more perfect than it was a year ago. There are many new specialities, those introduced with the New Year including an electric horn ; a new accumulator for traction purposes, wherein the plates or grids are constructed of an insulating material instead of lead, the result being greater capacity for less weight and much longer life ; an improved two-way switch for motor work. Amongst the past year's contracts an important one was for speed indicators and mileage recorders to the Walthamstow electric tram-cars.

Reviewing generally the replies received, there are two or three points repeatedly brought into evidence. Prominent among these is the aspect given to competition—home and foreign. In this connection we have received the following contribution from a member of a well-known firm who for sufficiently good business reasons prefers to remain anonymous.

"It would appear that foreign competition has not troubled us much in the past year. In fact there is a decided opinion that foreign competition cannot live, or in any way rival the very great competition that exists in this country itself. In this connection we find that the keenest competition exists with certain English firms who have in the last year or two enormously increased their works facilities and who are apparently afraid to face the question of refusing unremunerative work and are therefore taking work at a loss, and it is these people who, in their frantic efforts to fill their shops, absolutely regardless of the total cost of the finished product, have caused the low prices to rule that are at present obtainable for electrical machinery. Manufacturers whose determination it is not to work at a loss, but to be satisfied with even only a minute percentage of profit in these hard times, have found in scores of instances during the past year that when prices have been compared there are one or two firms who quote prices which have been as much as 20 per cent. below those of themselves, and as we know the value at cost of the material and labour in the plant offered, those firms who have quoted these low prices must be working at a loss; in fact, it is commonly talked of as 'So-and-so has dropped so much during the last year.'

"Such methods are not businesslike in any way, and there is no doubt that this state of affairs is one of the most troublesome factors in the electrical trade. Some of the so-called 'salesmen' connected with these 'cutting' firms would be better termed 'givers away.' They seem to have no idea of selling upon merits or reputation, but only on price, and were these gentlemen on commission and the prices to be paying ones, there would be a great addition to the 'unemployed' ranks.

"Depending upon being able to quote the lowest prices has never resulted in a firm building up a good and lasting connection, for the class of buyer that is attracted by low prices only will leave a manufacturer just as soon as another maker offers him a lower price.

"If a firm gets a reputation for being the cheapest in price it will find it an exceedingly difficult matter to ever again command higher figures for its manufactures.

"It is a most assured thing that trade does not depend, in the main, on price only. The factors of quality and business reputation are more important and, these being good, will, if coupled with personal cultivation on the part of the manufacturer's representative, time after time take away orders when lower prices are bid by other makers. Certainly the man who cuts gets a lot of work at the time, but just watch his business and you will find that when he has got a shop full of work and proceeds to put up prices, then his orders fall off and his trade is made up of 'ebbs and flows': the 'flows' resulting from cutting of prices are financially disastrous by the over-pressure of work at that moment and the consequent overtime, &c., coupled with the low prices; and the 'ebbs,' by the heavy standing charges continuing during the scarcity of work, are equally unsatisfactory. Such a concern will find that the nett result of a period of such "ups and downs" is worse financially than if they had set their faces against such cutting and spent the money so wantonly lost in cultivating a sounder class of trade and acquiring or training representatives who could sell upon other points than price only.

"Then again there is evidence as to short-comings on the part of consulting engineers and public buyers. It would seem that there are a few black sheep still among that generally honourable body, consulting and municipal engineers, and these parties in specifying for plant so draw up the matter that it is either evident or semi-evident that a particular firm's plant is required; either there is a friendly feeling or even a more tangible consideration at the back of such matters; but it is very galling to any but the favoured manufacturer to find that all the hours that his design, drawing, and estimating departments have put in in the hope of fair consideration of their tender, is even worse than wasted, because in some cases insult is added to injury, in that other makers are asked for further detailed information, which has afterwards mysteriously found its way into the archives of the favoured tenderer.

"Assuming that in some cases there is an absolutely honest belief in the virtues of one particular make of goods, would it not be as well in advertising for plant to say it was 'for the supply and delivery of plant, &c., to be made by Blank & Co.'? This would then save anyone but 'Blank's' time.

"At the same time it still remains in every way unfair to specify anyone's make unless it is an article which is a monopoly and can be supplied by one party only. In plant generally, whatever an engineer thinks is the best is not necessarily better than others. There are some engineers who, through an early training in a period when there were certainly only a few good, say, dynamo makers, allowed their training to cease so soon as a comfortable job was found, and these men believe therefore that there can still only be the said reliable makers of dynamos; this is at the back of some of the one-sided and unfair specifications.

"Had these men kept themselves *au fait* with what was going on in the manufacturing world, they would have seen that evolution was working somewhat more quickly in this field than in their own, and that new firms were coming forward capable of supplying their needs in at least as satisfactory a manner as the old ones could.

"Many such men argue that, because a concern have perhaps not previously made a machine of a particular size, they cannot do it, and they are ruled off. Had there been a fair mind at work, they could have inspected the designs and works' facilities, and by guarantees have ensured that their (the engineers') employers' interests were safeguarded. Has this class of man ever speculated what might have happened at the 'flood' if his way of doing things had then obtained, and the Almighty had asked Noah 'what previous experience he had had of navigation'?

"Another point is that many engineers when they want a machine sit down and try to tell the maker how it should be made, telling him that the shaft shall be 'truly turned,' bearings 'accurately bored,' and stampings 'insulated from each other by paper.' Now does this party think that if he did not specify such details the manufacturer would take a delight in turning out oval shafts or elliptically bored brasses, or that he would polish up each stamping before clamping it up? When the manufacturer reads such specifications he gets one of the few smiles that are permitted in these strenuous days, and remembers that the party perhaps served his time in some old shop in the 'eighties' in the days of ring windings and red-painted field coils, and knows that his subsequent visits to dynamo shops had consisted in working hard smoking cigars on a test bed during some official test. But at the same time we wonder why such an individual does not say, 'I want such-and-such an output; quote me, and tell me how you propose to make it.' The manufacturer could then show him that a ground shaft was more accurate than a plain turned one, and a bored and reamed bush better than a plain bored one, and that paper between stampings has been as extinct as the Dodo since slotted cores came in.

"Again, when he wants a motor, why does he fix on such speeds and outputs as no one makes as standard, and why does he expect a totally enclosed machine for about 10 per cent. more than an open one?"

The Editor of The Electrical Magazine will be pleased to supply readers with any desired information respecting the various firms and their specialities referred to in the foregoing reports. Address :

Intelligence Department,
The Electrical Magazine,
4, *Southampton Row, London, W.C.*

"Santoni" Flame Arc Lamp.

D. Santoni & Co. (1906), Ltd.

The "Santoni" intense flame arc lamp consists essentially of two converging carbons, the feed of which is controlled by a differential coil, releasing a clockwork as required. A blow-out coil keeps the arc well at the tips of the carbon, and thus ensures a perfectly shadowless arc.

The following description of its parts and operating principles will be readily followed by reference to the illustration, which shows the interior construction of the lamp.

A series coil *K* and a shunt coil *C* are wound as a solenoid on one reel; the plunger of this electro-magnet is a prolongation of the rod *R*. It passes up through the solenoid, and is so fitted as to have an easy upward and downward motion in the coil. The core is fitted with an arm *I*, which serves to lift the weight *A* and so release the escapement lever *B*. By the release of the escapement lever the clockwork begins to turn in a counter clockwise

READERS PLEASE NOTE—With the desire to bring the Reports herein as up to date and complete as possible, the publication of the current number has been deferred to the date on which it is now issued. Subsequent numbers will, of course appear about the middle of the month as usual.

direction, allowing the copper suspension cords to unwind simultaneously, and therefore the carbons to feed by their own weight.

In order that the core *RI* should not unduly influence the feed by slight variations in current or voltage, its motion is damped by a suitably designed dashpot *H*, fitted with a graphite piston.

The shunt coil is assisted in lifting the plunger by the spring *X*, and by judicious adjustment of this spring by means of a screw the exact tension of the spring and the voltage of the arc can be fixed.

The automatic shunt cut-out *Y Z* is interlocked with the shunt coil, and is adjusted in such a way that the pin *U*, fixed on the wheel *F*, will just lift the contact *Y*, and thus open the circuit when the carbons have burnt out.

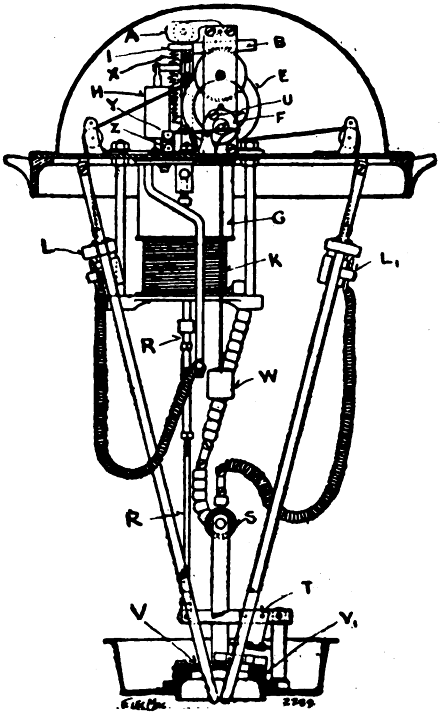
In the off position the carbons do not touch, and are about $\frac{3}{8}$in. below the arc chamber and $\frac{5}{16}$in. apart from each other. As soon as the current is switched on, the shunt coil will lift the rod *R*, and thus rock the fork lever *T* sufficiently to allow contact of the carbons. The rush of current through the series coil *K* will then pull the rod *R* downwards, which by separating the carbons will create an arc of the proper length. Two fire-clays *V* and *VI* hold the carbons in their proper position, the former being fixed, and the latter being provided with a movable brass slide to allow for the sideward motion of the carbon in opening and closing the arc.

The blow-magnet *S* keeps a hemispherical arc well at the extremities of the carbons, while the strong iron economiser or reflector throws all the stray light in a downward direction.

The flexible connections of the lamp are continuously insulated by threading substantial glass beads on them as shown. This method has proved very effective, the glass beads being in no way injured by the products of combustion of the carbons.

The re-carboning of the lamp is effected by pulling the bob *W* downward, thus the wheel *E* is rotated in a clockwise direction, the copper cord is re-wound round its periphery and the carbon holders L, L_1 drawn upwards, until they butt against the bottom of the clockwork chamber. The new carbons can then be inserted into the holders, and clamped by the thumbscrews. To permit of the carbons working satisfactorily when the current is switched on, they should be lowered $\frac{3}{8}$in. below the bottom part of the economiser, and $\frac{5}{16}$in. apart from each other as shown in the illustration. This is accomplished by lifting the rod *R* sufficiently to allow the lever *I* to work, and permit the escapement lever *B* to come into action.

The "Santoni" intense flame arc lamp has proved itself to be one of the most successful of the several types of flame lamps now on the market, and is rapidly coming into great favour. From the above description readers will gather that it is extremely simple in its operating parts, and that the principles entering into its construction are such as to permit of very ready adjustment and repair—a most important feature to be considered in every case when purchasing a new type of arc lamp.



DRAWING SHOWING THE PARTS AND OPERATION OF THE "SANTONI" INTENSE FLAME ARC LAMP.

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Gas Producers.

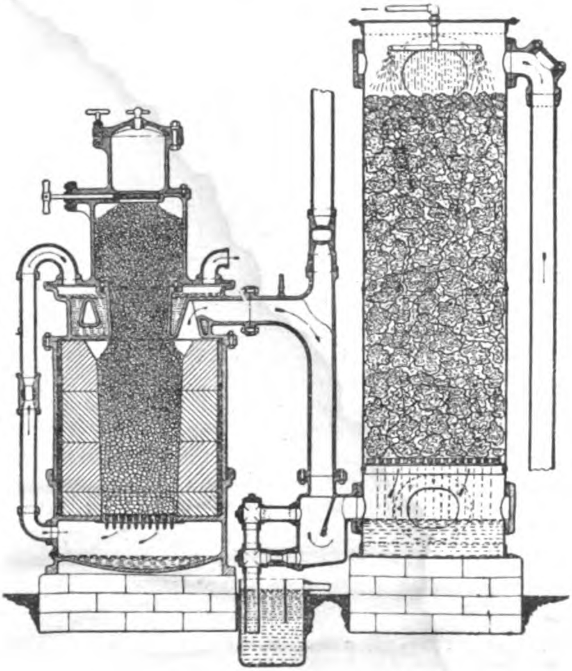
Tangyes, Ltd.

THE firm of Tangyes is known the world over in connection with gas engine manufacture, and their many years' experience in this branch of engineering have earned them an enviable reputation for general excellence. Keeping in touch with progress, the company was among the first to introduce the combined gas engine and suction gas power plant. The Tangye suction gas producer has achieved very considerable success, owing doubtless to its extreme simplicity of construction and its economical working. The illustration herewith shows in section this type of producer. Briefly described it consists of a generator combined with the small boiler or vapour chamber, a coke scrubber or washer of ample dimensions, and an expansion chamber. The generator of cast iron has a fire-brick lining further insulated from the case by a packing of sand. Near the top of the generator is the annular vapour chamber which, partly filled with water, is heated by the generator gases. The fuel used is either anthracite or coke. Reference to the illustration will show the detail of the producer arrangement and the process of the producer. Drawn in through the bend above the vapour chamber passing over the heated water, the mixture of air and steam descends through the side pipe and passes upwards through the heated fuel in the generator. From the generator it passes to the scrubber, through which it ascends, passing out into the expansion chamber, and then on to the engine. The waste water from the scrubber passes away through a water-seal box. The flow through the producer is of course regulated by the demands of the engine, which sucks or draws from the producer as required. The expansion chamber is introduced so as to equalize the draught of the engine and so maintain a more steady flow through the producer.

The simplicity of the apparatus is evident. Numerous tests as to its economy in fuel consumption and maintenance have shown that it leaves nothing to be desired in these directions. For instance, a six hours' run of a size D Tangye suction producer in combination with a gas engine developing 21.11b.h.p. showed a fuel consumption (anthracite peas) of not more than 0.785lb. per b.h.p. hour. It may be taken as a general rule that the fuel consumption when using anthracite does not exceed 0.9lb. per b.h.p. hour in ordinary service, meaning with the average price of anthracite in this country (20s. per ton) not more than a cost of 0.1d. per b.h.p. hour. These remarkably low figures account for the extraordinary development which has come about in the use of gas engines working in conjunction with suction producers for comparatively small power installations. Comparing the above price of 10b.h.p. hours for one penny with the corresponding price of power with gas engines on public supply mains with gas at a price of 2s. per thousand, the cost per b.h.p. hour would be about five times as great with the public supply as with the suction plant.

As to the capability of the Tangye suction producer for long runs and low maintenance charges, a D size suction producer running continuously for six days and six nights in conjunction with a Tangye engine developing an average power of 16.9b.h.p. showed that the cost of working with this average and moderate load did not exceed one penny per hour for 10b.h.p. Such figures and tests speak for themselves as to the value of this method of power generating.

It will be seen that the suction type


SECTIONAL ELEVATION OF THE TANGYE SUCTION GAS PRODUCER.

of producer is particularly adapted for small-sized units, the process being a continuous one and the attendance required practically nil. The fuel feeding down in the generator automatically, no constant fire attendance is necessary. Where a number of gas engines require to be fed from the one gas plant, pressure producers have the advantage. This firm also makes a speciality of the pressure type of gas producer, their designs exhibiting many original and commendable features.

It should be remembered that it is always advisable when installing producer and gas engine plants that the latter should be properly designed for the combination so as to ensure the best results. The engines built by Messrs. Tangyes for this service are expressly designed for their work. They have particularly large gas valves and passages, high compression and adjustable ignition, together with quick regulation of air and gas feeds.

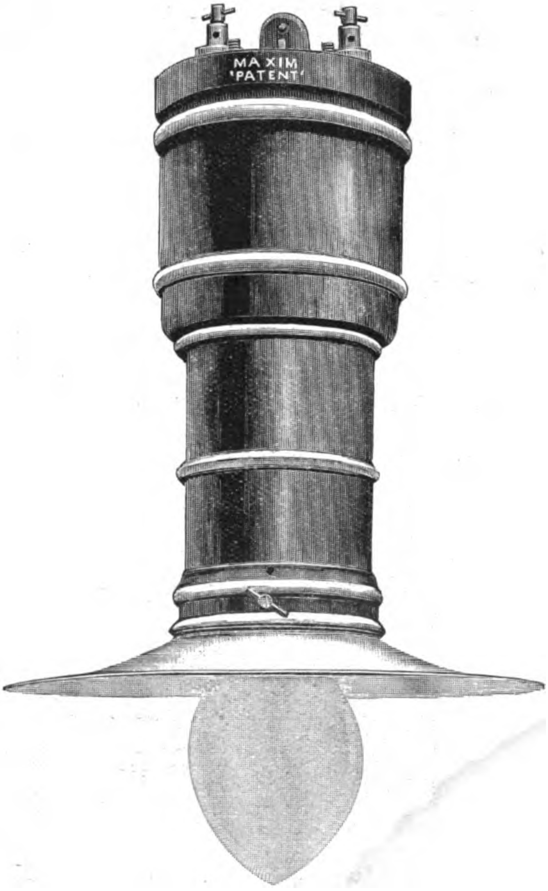
In gas engine construction this firm has kept well abreast of the times. For instance, their most modern type of high-power engine is of the three-cylinder vertical type, each cylinder working on the "Otto" cycle, and the governing being on the fly-wheel "throttle" principle. The crank chamber is enclosed, but fitted with doors sufficiently large to permit of the easy removal of any piston. The main bearings of the crank shaft are accessible and can be taken out without removing the shaft. As a rule with engines of this type and large sizes the cooling water is forced through the cylinder jackets, either by a special pump in combination with a cooling tower, or from pressure mains.

◆

Arc Lamps for Railways.

Maxim Electrical Company, Ltd.

SINCE the Maxim arc lamp installation of the Metropolitan District Railway it is interesting to note that all the electric tube railways have adopted the Maxim arc lamp for station lighting, and that the L. and S. W. Railway and other railways have also adopted this same type of semi-enclosed arc-lamp. The lamps are usually run four or five in series upon power circuits; each lamp is entirely self-contained and interchangeable. The Maxim Company have introduced a substitutional resistance and cutout, which are perfectly satisfactory in working, and sufficient to absorb the extra voltage should one or more of the lamps in a circuit fail from any cause.



THE MAXIM ARC LAMP.

The illustration herewith is of the type of lamp used on London's latest "Tube," the Great Northern, Piccadilly, and Brompton Railway, the style of case of which is quite new, and as will be seen is certainly very pleasing.

The case is of steel, coated inside and out with a hard vitreous enamel; the lamp is extremely durable, and is ventilated but weather-proof.

An Unequalled Opportunity.

The attention of Manufacturers is particularly directed to the First White Page of this number.

Hopkinson-Ferranti Steam Valve.

J. Hopkinson & Co., Ltd.

THE illustration below, Fig. 1, practically tells the story of the value of science in the construction of even such a detail as a steam valve. The smaller sized valve has the same free steam-way as the larger one: the former is the recent invention of Mr. Ferranti, and is the outcome of our greater knowledge of the laws governing pressures and velocities of steam; the other valve shown is an ordinary parallel slide valve having an orifice superficially equal to the pipe line it is intended for.

The principle of the Hopkinson-Ferranti valve is that at the entrance to the valve the steam is compressed in a converging channel or nozzle, and its pressure so converted into an increased velocity at which it passes without frictional loss through a small valve area, emerging into an expanding cone of correct form, in which the just added velocity is reconverted into the original pressure. This, in a few words, is the principle of the new valve; put into practice, however, very careful designing is necessary, so as to ensure there being no frictional loss in the valves intended for any particular service. It has been the usual practice, wherever economy is desired, to always have the steam valve passage at least equal to that of the pipe line; to insert valves of smaller openings introduced losses, and in many cases where there are several valves in the steam transmission from boiler to engine, the resulting total frictional loss becomes very excessive.

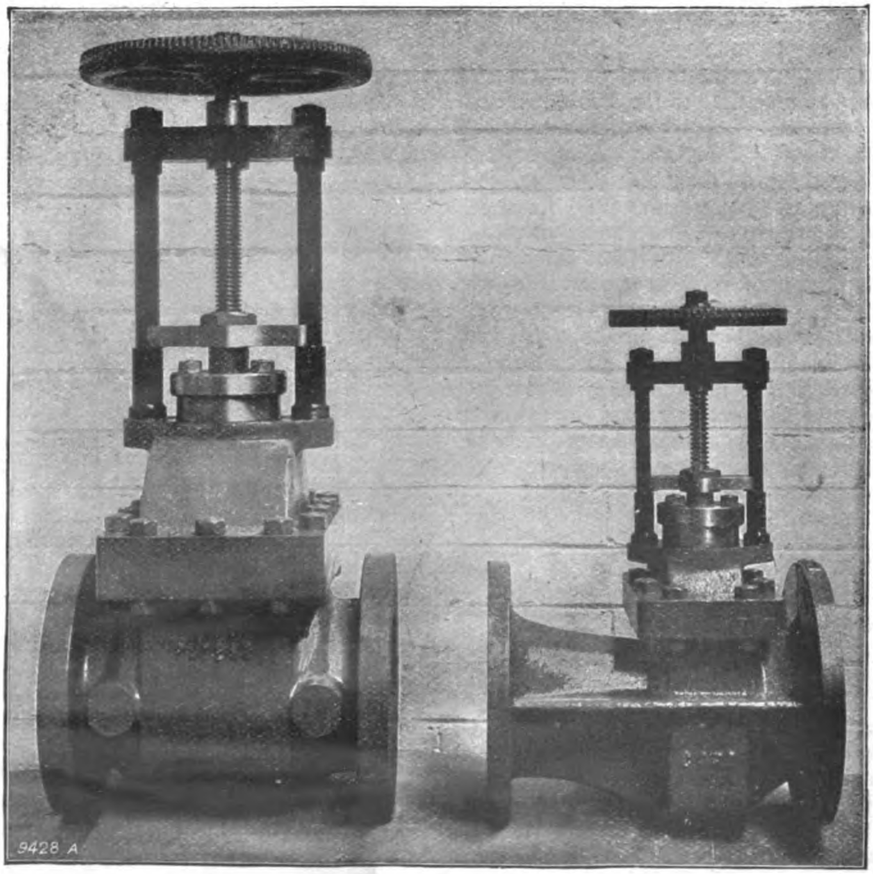
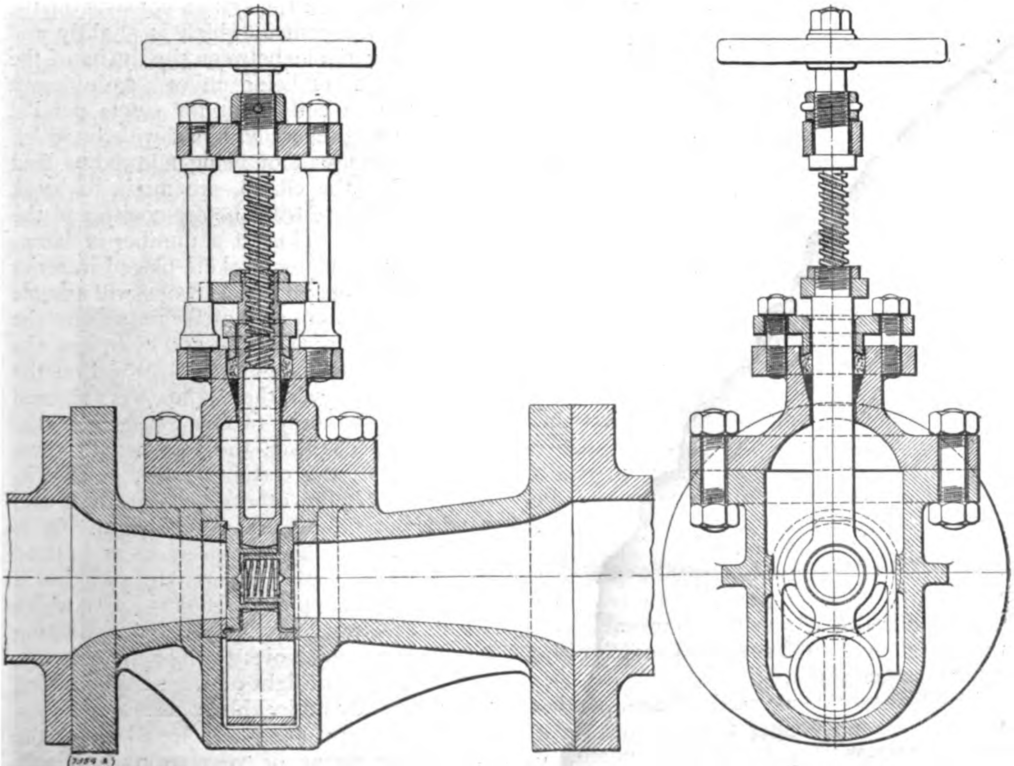


FIG. 1. COMPARATIVE SIZES OF THE ORDINARY PARALLEL SLIDE VALVE WITH THE HOPKINSON-FERRANTI STEAM VALVE FOR SIMILAR SERVICE.

Steam enters the valve through the shorter nozzle, which practice has proved should be so proportioned that its diameter at the small end or throat should be half that of the pipe line, that is one-fourth of its area. The moving parts of the valve at the throat of the nozzle are of the well-known design general in Hopkinson valves. The parts are made of their "Platnam" metal, the slide consisting of two equal rings mounted in the one frame, which moves in the slides. The upper ring is closed by lids or discs held against the valve sets by an internal spring, and serves to close the valve; the lower ring is open, and provides a full free-way when the valve is opened. It is particularly important in the new valve that the latter open ring or tube shall be in exact alignment with the nozzles when the valve is full open, as it is here that the steam velocity is greatest and friction must be reduced to a minimum if loss is to be avoided. As proof of this, an experiment made of substituting in the throat of the nozzles of a new valve an ordinary valve of the same orifice as the nozzles in place of the proper operating parts, showed a serious frictional loss in pressure. Great care, therefore, is taken by the makers to ensure a smooth and correctly aligned passage through the valve. The nozzles are of the correct shapes and dimensions, accurately and smoothly finished, so as to ensure the equal conversion and reconversion of energy as velocity and pressure, and to prevent losses by eddies.

The result is that the valves manufactured by Messrs. Hopkinson under their patents have only small working parts, and at the same time provide a steam-way in which the drop in pressure is negligible, and which is capable of carrying the heaviest overloads. Other advantages of these valves are small size and weight—the weight is about half that of an ordinary straight-through steam valve—small leakage losses, reduced to at least one half of that of an ordinary valve, because of the smallness of the valve seats, and the stronger and better work which can be put into the parts of reduced size; the shape of the valve permits



FIGS. 2 AND 3. SECTIONAL VIEWS OF THE HOPKINSON-FERRANTI STEAM VALVE.

of its being put direct into a standard pipe line, without the necessity for special pipe flanges of larger diameters and bolt-centres than the standard. A further important feature is that with the Hopkinson-Ferranti stop-valve no bye-pass is necessary: the conical entrance to the valve and the small valve opening make the flow practically proportional to the turns of the hand-wheel, consequently there is no rush of steam at the opening of the valve; moreover, the effort required for operating the valve is, owing to the small size, only about one-eighth of that required for ordinary straight-through valves for similar services.

A large number of this valve are already in use in central stations, collieries, steel works, and on various installations; in every case it has proved entirely successful, and can be confidently expected to have a great future before it.

◆

Supply Meters, Demand Indicators, Arc Lamps, &c.

The Reason Manufacturing Company, Ltd.

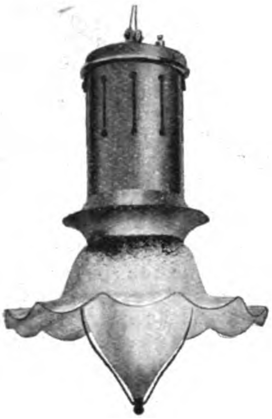
This company, whose headquarters and works are at Brighton, has always been distinguished by a progressive policy in the introduction of inventions. It was the first to bring out the maximum demand indicator, and this company's indicator is in use in about 75 per cent. of installations of electric supply in the United Kingdom.

Some five years ago the company placed on the market Wright's mercury electrolytic meter, which was the first electrolytic meter to combine the accuracy peculiar to this type of meter, with absence of its chief objections. The working part consists of a hermetically sealed glass cell, in which mercury is deposited from an anode of mercury on a cathode of iridium, or similar metal. The mercury deposited falls into a measuring tube provided with a scale, on which the units consumed are read off. One hundredth of the total current passes through the cell, which is in parallel with a low resistance shunt.

The first meter ever used in house services was the Edison copper meter, and all electrolytic meters, the lineal descendants of this, contained open vessels of chemical fluids, until the advent of the Wright meter. The Wright meter was an enormous success, and a very large number of them were sold. A defect, however, appeared when it had been in use for some time, owing to the electrolyte employed not being stable under all conditions of practical use. A year ago the company introduced the Hatfield patent electrolyte, which has been examined by the highest scientific authorities, and pronounced to be undoubtedly permanently stable. With the new meter, therefore, it is clear that there is nothing whatever that can suffer any alteration by the lapse of time or by ordinary use within the limits of 50 per cent. overload, and that therefore this meter has practically the same permanence in calibration and resistance to wear as a mercury thermometer.

This company holds the Lewis patents for arc lamps. These patents comprise a system, and the only system known at present, by which enclosed arc lamps can be run in series without the use of shunt coils. This means both reduced price and a very much greater freedom from breakdown. Briefly explained the system consists, firstly, in a magnetic control which is slightly and definitely variable between the limits of the strike, instead of being uniform as in lamps without shunt coils built for single parallel running; and secondly, in a device by which the lamps, instead of being allowed to feed by slipping the clutch, are made to break their arcs and restrike before coming to the feeding-point. Thus if a number of lamps with this variable control are placed in series and started up, all the carbons will assume the same position, as the current will be the same through each lamp, and therefore the position of the core in each coil will be the same. If, however, these lamps were allowed to burn without any further addition to the ordinary mechanism, the time would come when one of the clutches would release its carbon before the others, and then the arcs would not be of the same length. It is therefore necessary to prevent any lamp feeding by slipping its clutch, and this is done by a simple magnetic lock which arrests the travel of the core. This action occurs about once every two or three hours, and the flicker of light on the restrike taking place is hardly noticeable.

These lamps are made in all sizes, the large lamps being of very strong and substantial design, and the miniature lamps

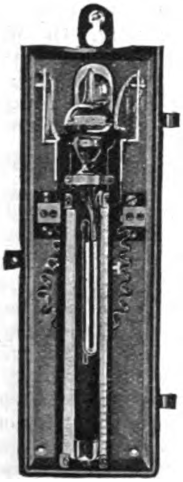


The Lewis Miniature Lamp.

not too small for good working, and very artistically finished. Features in the design are, first, strong control; second, strong framework and high insulation; third, a separate resistance, the conclusion having been definitely reached that it is impossible to place the line resistance within the lamp without liability to breakdown.

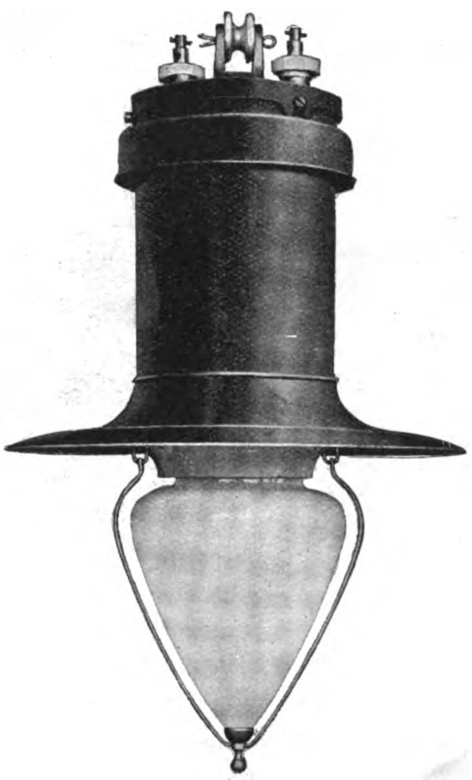
The latest lamp brought out is a new flame lamp, which is the first successful lamp of its kind put on the market with simple direct magnetic control of the carbons in place of clockwork or cords and pulleys which have been abandoned in the evolution of the ordinary arc lamp.

This company is the sole licensee of the Merz maximum demand Indicator, which must come into increasing prominence in the immediate future with the rapid increase of power supply in bulk which seems likely to take place. The ordinary indicator cannot be adapted without considerable waste of energy to a large installation, but the Merz indicator is a simple attachment which can be fitted to any motor meter. It registers the greatest number of revolutions of the motor spindle which have taken place within any predetermined period, such as an hour, and thus combines the valuable feature of lime lag so well attained in the Wright thermal indicator with the absence of energy loss. Another advantage which it possesses is that its calibration is deducible by calcutation from that of the meter, and is therefore beyond dispute.



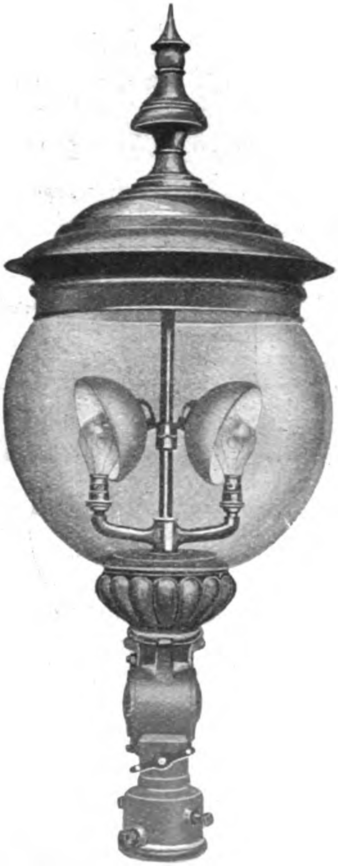
The Reason Electrolytic Meter—in Case with Lid Removed.

The Cell of the Reason Electrolytic Meter.



The Lewis Series Lamp—5amp. Size.

This company supply street lighting fittings with specially designed reflectors, and has a very neat arrangement for the conversion of gas lanterns to electric light, a process which is bound to take place with increasing rapidity on the advent of metallic filament lamps. A system of highly efficient reflectors adopted will make the superiority and efficiency of electric lighting with the new lamp overwhelming.



The Reason Incandescent Lantern with Patent Reflectors.

The Reason Company's prepayment meter still remains one of the most successful ever brought out, and it is hardly necessary to mention the company's well-known fuse boxes, of which about a quarter of a million have been sold.

Trade Notices.

Mammoth Crane Controllers. — The Adams Manufacturing Company, Ltd., recently dispatched from their Bedford works three controllers, which are the largest automatic crane controllers ever installed in this country. They went to Craven Brothers, the well-known crane makers, of Manchester: their ultimate destination will be one of the largest steel works in Sheffield, where they will be used for handling, with lightning rapidity, white-hot steel ingots weighing up to 120 tons.

These controllers are 525h.p. Hitherto a 100h.p. crane controller has been considered a very large size, and few if any of these are entirely automatic.

The entire operation of these enormous crane controllers is by means of a small master switch, which can be easily operated with one hand. This switch transmits through solenoid controlled contractors, which handle the main current between the supply circuit and the motors; the normal current handled by these switches would be about 1200amps. The amount of current used for operating the contactor switches handling 1200amps. does not exceed ¼amp.

The largest like apparatus supplied for crane or ship derricks and controlled on similar lines were three 80h.p. controllers recently supplied for operating large derricks in connection with shipyards in Japan.

Agencies.—Johnson & Phillips, Ltd., advise us that they have entered into an arrangement with Messrs. Welding and Co., of 64, Stanley Street, Liverpool, and 8, Princes Chambers, John Dalton Street, Manchester, to represent them in the counties of Lancashire and Cheshire, and any enquiries sent to either of these addresses or direct to the Charlton Works will have their closest attention.

The agreement which Johnson and Phillips Ltd., had with Messrs. Scattergood and Johnson, of 7, Cookridge Street, Leeds, to represent them in the Yorkshire and Nottinghamshire area, has been terminated, and all enquiries and orders from these districts should be sent direct to Victoria Works, Charlton.

The £2000 Prize.—The Adams Manufacturing Company, Ltd., advise us that the prize offered by them and noted in the last number of The Electrical Magazine, is made for the first British-built aeroplane and engine, irrespective of that made by any particular firm. By this it will be seen that the prize offer is not confined to users of "Antoinette" engines, which Messrs. Adams make at their works in Bedford.

Important Foreign Order.—Crompton & Co., Ltd., have secured the contract from the Sudan Government for the complete electrical lighting and power installation required for Port Sudan to the specification of the consulting engineer, Mr. A. G. Marshall, 66, Victoria Street, S.W. The installation comprises: Three Paxman economic boilers with superheaters, and a Green's economiser. Two 200kw. and one 100kw. Allen Crompton steam dynamos suitable for lighting and traction purposes, each set being provided with an independent condensing plant; reversible booster and balancer; main and auxiliary switchboards, together with all the necessary cable connections. The whole of the steam, exhaust, feed water pipes, &c., together with the feed pumps, and feed water heater. A Tudor battery of 240 cells, the bare copper overhead lighting mains, with insulators and wooden poles. The whole of the plant is to be delivered, erected, and set to work.

LITERARY Section.

Including

Reviews of Books, List of Practical Works, Publishers' Notices, Standard Publications, WORLD'S ELECTRICAL LITERATURE, New Catalogues, &c.

Readers will find this Section invaluable. We shall be pleased to furnish further particulars regarding the Books dealt with herein, or to supply information concerning any other books. Communications requiring an answer through the post must be addressed to Literary Editor, ELECTRICAL PUBLISHING CO., LTD., *4, Southampton Row, London, and accompanied by stamped envelope.*

A PRACTICAL HANDBOOK.

The Treatment of Storage Batteries. BY R. W. VICAREY. (LONDON: THE ELECTRIC ACCUMULATOR, 15 QUEEN STREET, CHEAPSIDE, E.C. PRICE 2s. 6d. NET.)

There is considerable scope for a reliable and easily understood handbook dealing with the practical care of accumulators. The author of this work has essayed to supply this want and has succeeded—so far as the text of his book is concerned. Our first impression on receiving the book was one of disappointment with its size of page and paper cover, and after perusing the contents we cannot but think that the publishers have made a mistake in this. It is however "in the eating" that this book proves its value. The subject is treated thoroughly, and illustrations help along a simply written collection of opinions and facts based on actual experience of all types and sizes of accumulators as installed, and not from the test-room or trade-catalogue point of view.

The subject is divided up into a series of complete articles on each phase of battery installation, maintenance, troubles and cures, and in short nothing in the general handling of accumulators seems to have escaped the author.

The book, being of reasonable price, having no competitor, and filling its object well, should have a large sale. Although the author speaks of having known all grades of skilled labour, even to the woman domestic, to have had charge of battery installations—and by inference has tried to write for the guidance of these people—it must not be taken that the book will be superfluous to the legitimate engineer; indeed there are very many electrical engineers of high status who will find this work extremely useful. It will be generally welcomed by all who have charge of plant and by the student, who as a rule is too weighted with theory and requires such practical information as is in Mr. Vicarey's book to balance things up and make him clearer in his knowledge and of more use in the workaday world.

ESSENTIALS.

With the close of the one year and the awakening of its successor came the customary annuals, each serving its purpose of gathering the tangled threads of a dead year's incidents and weaving them into a fabric, the colour and texture of which for future guidance can be readily compared with the similar records of by gone times.

It is perhaps unnecessary to indicate how valuable these books are to those who are determined to keep pace with the times and who, understanding that "time is money," acquire the habit of referring to them for assistance in doubt and difficulty. As a rule, the wide scope of each year-book, or annual, prevents an adequate review. Readers may take it, however, that those selected for mention below are the best of their kind, and indispensable.

Who's Who, 1907. (LONDON: ADAM & CHARLES BLACK, SOHO SQUARE. PRICE 10s. NET.)

This work is known to every progressive business man as an indispensable work of reference. The present edition is brought up to the times and gives short biographical notes of all the leading men of the day, their spheres in life, &c. Some idea of the scope of the work is conveyed by the fact that it includes about 2000 pages of reading matter and gives useful and interesting information concerning about ten times as many prominent individuals.

Who's Who Year Book for 1907. (LONDON: ADAM & CHARLES BLACK, SOHO SQUARE. PRICE 1s. NET.)

This little book is made up of the tables which were formerly such a popular feature of "Who's Who" itself, forming the original nucleus of the book, which developed on different lines into a biographical annual. The new edition contains several tables never before published, and it has been brought thoroughly up to date.

The Englishwoman's Year Book and Directory. EDITED BY EMILY JANES. (LONDON: ADAM & CHARLES BLACK. PRICE 2s. 6d. NET.)

A work which makes a special feature of supplying information for the business woman and the business-like members of the gentle sex is certain of support. This is the twenty-seventh year of this publication, and it still upholds its reputation for thoroughness and accuracy in the very wide range of subjects treated.

Hazell's Annual for 1907: A CYCLOPÆDIC RECORD OF MEN AND TOPICS OF THE DAY: EDITED BY W. PALMER, B.A. (LOND.). (LONDON: HODDER & STOUGHTON. PRICE 3s. 6d. NET.)

The issue of Hazell's for 1907 contains several new and interesting features. In addition to its general record, it contains special articles written by experts, dealing with the principal events which have occurred in the world during 1906. Electrical engineering statistics and progress are reviewed, as are also all general trades. "Hazell's Annual" is of special value, and substantiates the claim of its proprietors that it is "The Indispensable Annual Volume" for every thinker, reader, or student.

The Daily Mail Year Book for 1907. EDITED BY PERCY L. PARKER. (LONDON, E.C.: ASSOCIATED NEWSPAPERS. PRICE 6d. NET.)

Electrical engineers are after all like everybody else, and even they are on the look-out for bargains and do contrive to find a little leisure wherein to improve the mind with general facts. This "Little Red Book" is overflowing with facts, and they are general. The subjects range from Simplon Tunnel to soap trust; politics, trade, home, colonial, and foreign questions of the moment—all are dealt with, along with such a large number of subjects as were surely never before collected into one volume. We cannot imagine anyone being disappointed with this wealth of good reading for sixpence.

POPULAR SCIENCE.

The Manufacture of Light. BY SILVANUS P. THOMPSON, D.Sc., F.R.S. (LONDON: MACMILLAN & CO., LTD. PRICE 1s. NET.)

The author's name is full guarantee as to the worth of this work: Professor S. P. Thompson has long since earned his reputation as one of the most able speakers and writers of the electrical profession. This little book is the record of a striking address which the author delivered before a large audience at the last year's British Association meeting held in York. The subject is covered in a remarkably thorough manner, theoretically and practically, considering its necessary limitations of space and treatment in this instance. The structure of light and simple explanations of radiation phenomena and rules are brought forward to practice and an accurate and easily understood description and comparison of all known forms of artificial light making—glow-worms, candles, oil, gas and electricity—all are brought before the reader: figures and costs are freely interspersed, thus giving the book a practical value. It is seldom that one comes across a scientific book which is really entertaining as well as technically instructive: when such is found it is to be carefully noted. This is one.

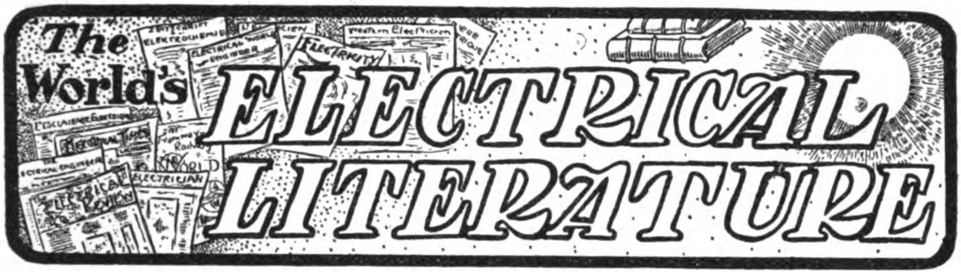
Publisher's Notice.

HARPER AND BROTHERS are about to add another volume to their series of electrical handbooks, "Elements of Electric Traction for Motormen and Others," by L. W. Gant. It is a work specially written and primarily intended for motormen, depôt foremen, inspectors, apprentices, and others employed on electric tramway systems, to serve also as an elementary text-book for students beginning the study of electric traction. In this work the fundamental, mechanical, and electric principles underlying electric tramway traction are dealt with in a simple and concise manner, and in such a way as to enable a motorman to obtain a definite and practical knowledge of the working and running of a car and the underlying reasons; special chapters being devoted to the application of motors to traction, electric brakes, &c. The work is illustrated by specially prepared diagrams.

"ELECTRICAL ENGINEERING."

Bearing this title with the New Year appeared the first issue of a new venture in electrical journalism. *Electrical Engineering* is a weekly newspaper, and its policy is sufficiently indicated by its title. It has certainly made a good start, the first numbers containing several valuable contributions by leading electrical men. The electrical profession is ever advancing by leaps and bounds. There is always room for a good electrical journal. We welcome this addition to our ranks and wish it every success.

NOTE.—*Owing to extreme pressure on our space we have been obliged to hold over until next month the reviews of several important books.*



The World's ELECTRICAL LITERATURE

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Power.

The Clyde Valley Power Company.	*Elec. Eng.*, 14/12/06.
High Tension Transmission.	*Elec. Eng.*, 14/12/06.
North Wales Power Company.	*Elec. Eng.*, 21/12/06.
The Care of Belts. C. J. Morrison.	*Can. Elec. News*, *Dec.*,/06.
Single-Phase Power. N. Harrison.	*Central Station*, *Dec.*,/06.
Motor-driven Machine Tools in Railway Shops.	*Elec. Wld.*, 1/12/06.

Traction.

The Great Northern, Piccadilly, and Brompton Railway.	*Elec. Eng.*, 14/12/06.
Leyton Electric Tramways.	*Elec. Eng.*, 28/12/06.
The Adaptability of Electricity in Foggy Weather on Railways. J. H. R.	*Elec. Rev.*, 21/12/06.
The Piccadilly Tube.	*Elec. Times*, 20/12/06.
Electric Signalling on Railways.	*Elec. Times*, 27/12/06.
The Proper Size and Voltage of Storage Battery Cells for Automobiles. F. B. Rae.	*Elec. Wld.*, 15/12/06.
The Great Northern, Piccadilly, and Brompton Railway.	*Try. and Rly. Wld.*, *Dec.*,/06.

Central Station Practice.

A 100,000kw. Steam Turbine Station. J. C. Thorpe.	*Power*, *Dec.*,/06.
Actual Turbine Results—Report on Condition after a Year's Use—Steam and Coal Consumption in Actual Service.	*Power*, *Dec.*,/06.
Management of Alternate Current Generators.	*Power*. *Dec.*,/06.
Gas-Engine Types. J. F. King.	*Power*, *Dec.*,/06.
Shift Engineers. W. M. Milnes.	*Elec. Rev.*, 21/12/06.
Notes on Turbine Erection and Operation	*Elec. Rev.*, 28/12/06
Modern Gas Producers	*Elec. Rev.*, 28/12/06.
Polyphase Systems of Generation, Transmission and Distribution. M. A. Sammett.	*Can. Elec. News*, *Dec.* /06.
One Phase of Advertising and Two of Electricity	*Elec. Times*, 13/12/06.

Lighting and Heating.

Incandescent Lamp Clusters and Bowls. J. R. Cravath and V. R. Lansingh.	*Elec. Wld.*, 1/12/06.
Transformation of Electric Power into Light.	*Elec. Wld.*, 1/12/06.
The Zirconium Lamp.	*Journ. f. Gasbel.*, 10/11/06.
Tests of Incandescent Lamps. L. B. Spinney.	*Elec. Wld.*, 15/12/06.
New Types of Incandescent Lamps. C. H. Sharp.	*Elec. Rev.*, *N. Y.*, 8/12/06.

Telegraphy and Telephony.

The Audion. L. De Forest.	*Teleph.*, *Dec.*,/06.
Causes and Remedies of Troubles in Common Battery Systems. C. G. Osborn.	*Teleph.*, *Dec.*,/06.
The Evolution of the Telephone. J. H. Winfield.	*Teleph.*, *Dec.*,/06.
The Original Morse Patent Covering the Invention of the Telegraph.	*Tel. Age*, 16/12/06.
Specifications for Rubber Insulated Signal Wire.	*Tel. Age*, 16/12/06.
Report of the Indian Telegraph Department (Gaz. of India), 1905-1906.	*Elec. Rev.*, 21/12/06.
The French Telephone Service.	*Elec. Rev.*, 28/12/06.
Silicon as a Wireless Detector.	*Elec. Wld.* 8/12/06.
Undamped High-Frequency Oscillations.	*Elek. Zeit.*, 22/11/06.
Seeing Electrically. W. L. Chamberlain.	*Elec. Rev.*, *N.Y.* 8/11/06.

Design and Manufacturing.

Recent Design in Direct-Current Switchboards. E. Schildhauer.	*Elec. Wld.*, 1/12/06.
Transformers with Variable Ratios.	*Elek. Bahn.*, 4/10/06.
The Single-Phase Induction Motor. A. Still.	*Elec. Wld.*, 8/12/06.
Carbon Brushes.	*Elek. Zeit.*, 15/11/06.
Armature Reaction in Polyphase Alternators. L. A. Herdt.	*Elec. Rev.*, *N.Y.* 1/12/06.
Practical Points on Polyphase Induction Motors. F. P. De Wilde.	*Power*, *Dec.*,/06.
Selection and Testing of Materials for Construction of Electrical Machinery. J. Epstein.	*Elec. Engineer*, 14/12/06.
A New Swedish Electrical Combine and its Products.	*Elec. Rev.*, 21/12/06.

Students.

Notes on a Graphical Proof of the Rule for Comparing Resistances, by the Kelvin Double Bridge. A. E. Moore.	*Elec. Engineer*, 28/12/06.

Electro-Chemistry.

The Extraction of Metallic Sodium. C. F. Carrier, Jr.	*Elec. Chem. & Met. Ind.*, *Dec.*,/06.
Platinized Platinum Anodes for Chlorate Production. W. Geibel.	*Zeit. f. Elektrochem.*, 9/11/06.
Electrolytic Precipitation of Gold. J. R. Withrow.	*Jour. Amer. Chem.*, *Soc.*, *Oct.*, /06.
Aluminium Cells and Train Lighting.	*Zeit. f. Elektrochem.*, 2/11/06.

New Catalogues

1906-1907.

The close of the year brought with it the customary series of calendars and novelties, all of which, without exception, were both useful and interesting. These effective advertisements included:

W. T. Glover & Co., Ltd.—A calendar in the design of a cable drum having the customary slips for each day, these slips exhibiting a grand store of electrical wit and wisdom in prose, rhyme, and illustration. This almanac is only for the first six months of the year; its continuation, a calendar appearing during the summer, will be something of a novelty.

Messrs. Glover also send us a useful little device in the shape of a three-minute sand-glass neatly mounted in an aluminium stand, which they designate a Telephone Trunk Call "Tell-Time."

Johnson & Phillips, Ltd.—An illuminated card calendar of attractive design and useful size.

The Hart-Accumulator Co., Ltd., present a neat desk blotting-pad finished in morocco leather: a useful office adjunct and of a quiet design suitable for any desk.

The United States Metallic Packing Co., Ltd., earned praise twelve months ago for their effective calendar. This year's effort, a bas-relief wall calendar, surpasses even that, and there can be no two opinions as to the new calendar being one of the most beautiful pieces of work ever produced in this direction.

The Allgemeine Electricitats Gesellschaft, Foreign Department, have resolved to keep their name before clients for a long time to come by presenting them with a useful letter weigher of the spring-balance type, fitted with dial.

Electrical Power Storage Co., Ltd., have again issued their annual desk fitment combining blotting-pad, calendar, diary, general postal information, &c., and accident insurance form. This is still one of the most effective New Year's gifts produced in the electrical industry.

Messrs. Geipel & Lange have selected a vest-pocket diary, combined with an insurance policy and a selection of useful engineering tables.

Siemens Brothers' Dynamo Works, Ltd., have also issued a somewhat similar, but larger-sized, pocket book. Gifts such as these are always useful, and hit the intended mark as effective advertisements.

The British Electric Transformer Co., Ltd., present a copy of the ever-welcome and useful "Whitaker" for 1907. The copy is of the "Edition de Luxe" character, gilt-edged and bound in padded morocco. This well-known firm is to be congratulated on their selection of a gift which is useful all the year round, and which is certain wherever it goes to remain in prominence for at least twelve months.

The Chloride Electrical Storage Co., Ltd., have hit upon a distinct novelty in the way of a useful ebonite match-box—a neat and always useful reminder.

The Western Electric Co., Ltd., have produced an attractive wall calendar.

Mavor & Coulson, Ltd., have also issued a neat and effective calendar displaying the firm's well-known electrical coal cutters.

Radiators and Lamps.—The Sun Electrical Co., Ltd.—Leaflet describing a cheap form of electric radiator of prices ranging from 25s. Catalogue (sectional) of incandescent lamps includes prices and information of this firm's well-known specialities, including standard and fancy bulb lamps, "Cryselco," tantalum and turn-down types; radiator, battery and other lamps of special shapes and sizes. We have also received this firm's complete catalogue (Section H) of electric radiators, and circulars dealing with their specialities in signs of various descriptions.

Accumulators.—The Chloride Electrical Storage Co., Ltd.—Circular No. 16 gives an illustrated and complete description of the "Entz" booster as installed by this company at the electricity works of the Greenock Corporation.

"Time Lag" Motor Starters, Switchers, &c.—The Switchgear Co., Ltd.—An instructive pamphlet written by Mr. J. G. Statter on the subject of proper devices for the protection of direct-current motors and their economical use, entitled "The Economical Use of Continuous Current Motors." We have also received a number of circulars illustrating this firm's specialities in switchgears. The "Time Lag" device is an ingenious type of electro-magnet having a telescopic armature or plunger working in conjunction with a dash-pot; the publications show its application to motor-starters and to circuit breakers. The Switchgear Company intimates that copies of these pamphlets can be obtained from them by anyone interested at a price of 3d. each, post free.

A New Works and its Products.—The Union Electric Co., Ltd., have issued an attractive publication, which has the commendable feature of telling its story entirely by illustration. Towards the close of last year the company entered into their new works in Southwark, in connection with which event a most enjoyable house-warming party was arranged. The guests were shown over the new premises, wherein were to be seen, in full operation, many specimens of the Union Company's products. Notable amongst these is the wide variety of arc lamps, ranging from Midgets for indoor work up to the most powerful lamps for street service; high-tension oil-immersed switch-gear, some with a simple and highly effective relay actuation and time-element automatic attachments; high-grade controllers, instruments, &c.

The works are characterised by their utilitarian form, strong construction, ample lighting, and plain finish; altogether they are designed on common-sense lines, and doubtless this spirit, which pervades the company's control, will ensure their great success.

Wiring Conduits.—Armorduct Manufacturing Co., Ltd.—A folder showing diagrammatically the expansion in Armorduct sales year by year since 1900.

Suction Gas Plant.—Alexander Oldham & Sons, Ltd., Dukinfield.—An illustrated leaflet setting forth the advantages of the "English" suction gas plant.

"Installation News."—Simplex Conduits, Ltd., have produced under this title what is in truth the first number of an interesting trade periodical. This is a distinct departure from the everyday catalogue, and a good deal could be said in favour of this enterprising method of gaining publicity.

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Alternating Currents.—An analytical and graphical treatise for students and engineers. By FREDERICK BEDELL, Ph.D., and ALBERT CUSHING CREHORE, Ph.D. Fourth edition, with 110 illustrations, 325 pages, 8vo, cloth. (New York, 1904.) 10/6 net.

Practical Electric Railway Handbook.—By ALBERT B. HERRICK, Consulting Electric Railway Engineer. Second edition, revised and corrected, with 329 illustrations, 460 pages, 12mo, leather. (New York, 1906.) 12/6 net.

Electrical Practice in Collieries.—By D. BURNS, M.E., M.INST.M.E., Certificated Colliery Manager, and Lecturer on Mining and Geology to the Glasgow and West of Scotland Technical College. A clear and concise introduction to electrical practice in collieries. Contents: Units of Measurement, Conductors, &c.—The Theory of the Dynamo—The Dynamo, details of Construction and Working — Motors — Lighting Installations in Collieries—Pumping by Electricity—Electrical Haulage—Coal Cutting—Miscellaneous Applications of Electricity in Mines—Coal Mines Regulation Act (Electricity)—Index. Second edition. In crown 8vo. Handsome cloth. With 30 new illustrations. 7/6 net.

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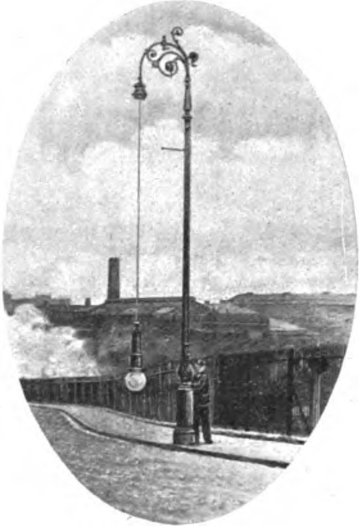

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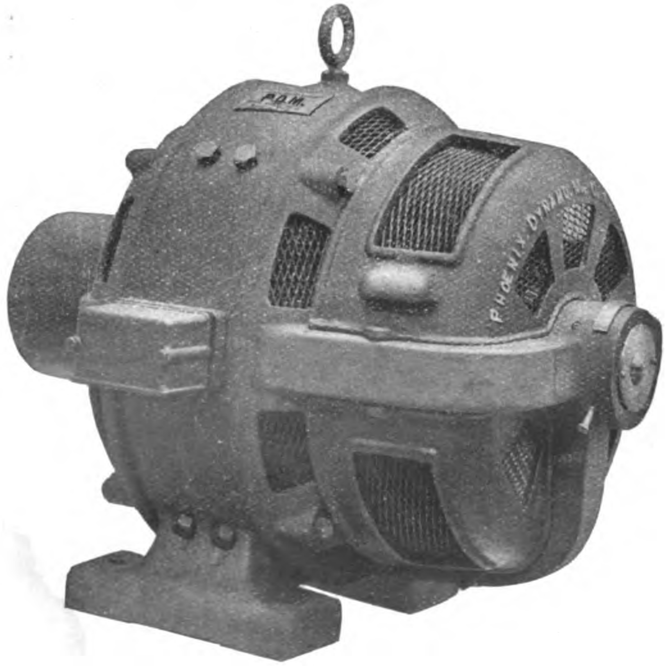

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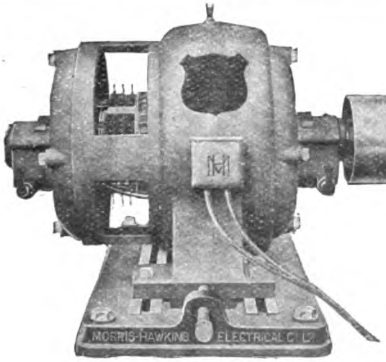

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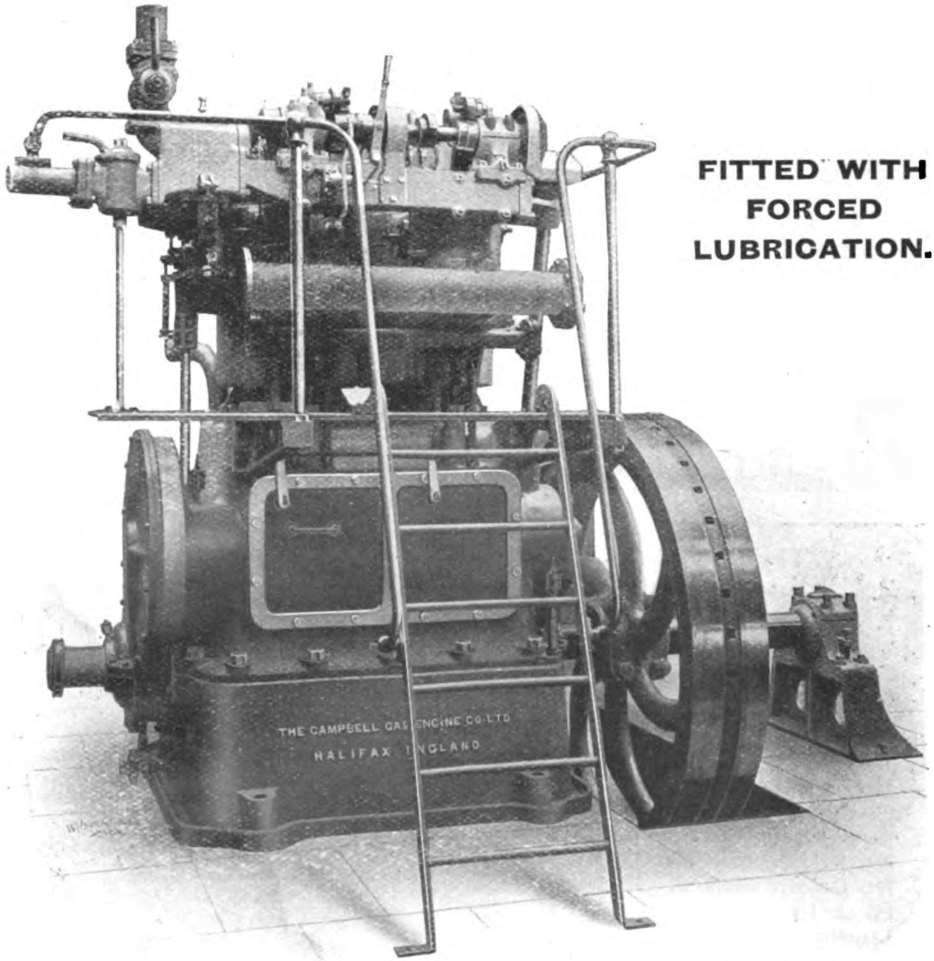

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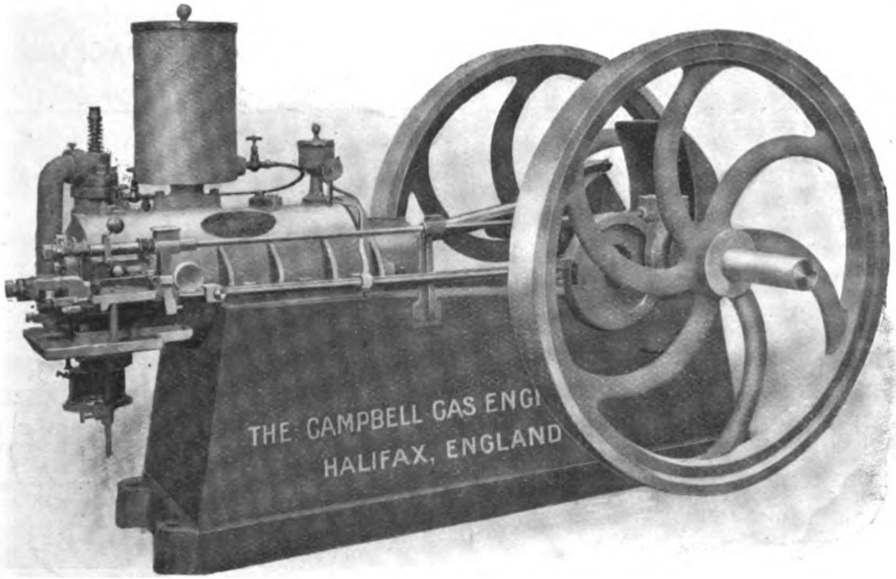

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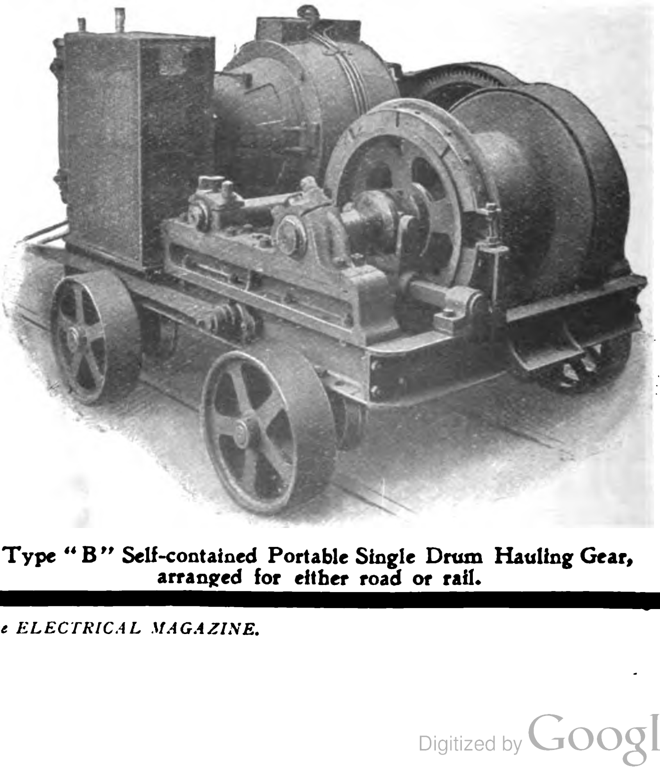

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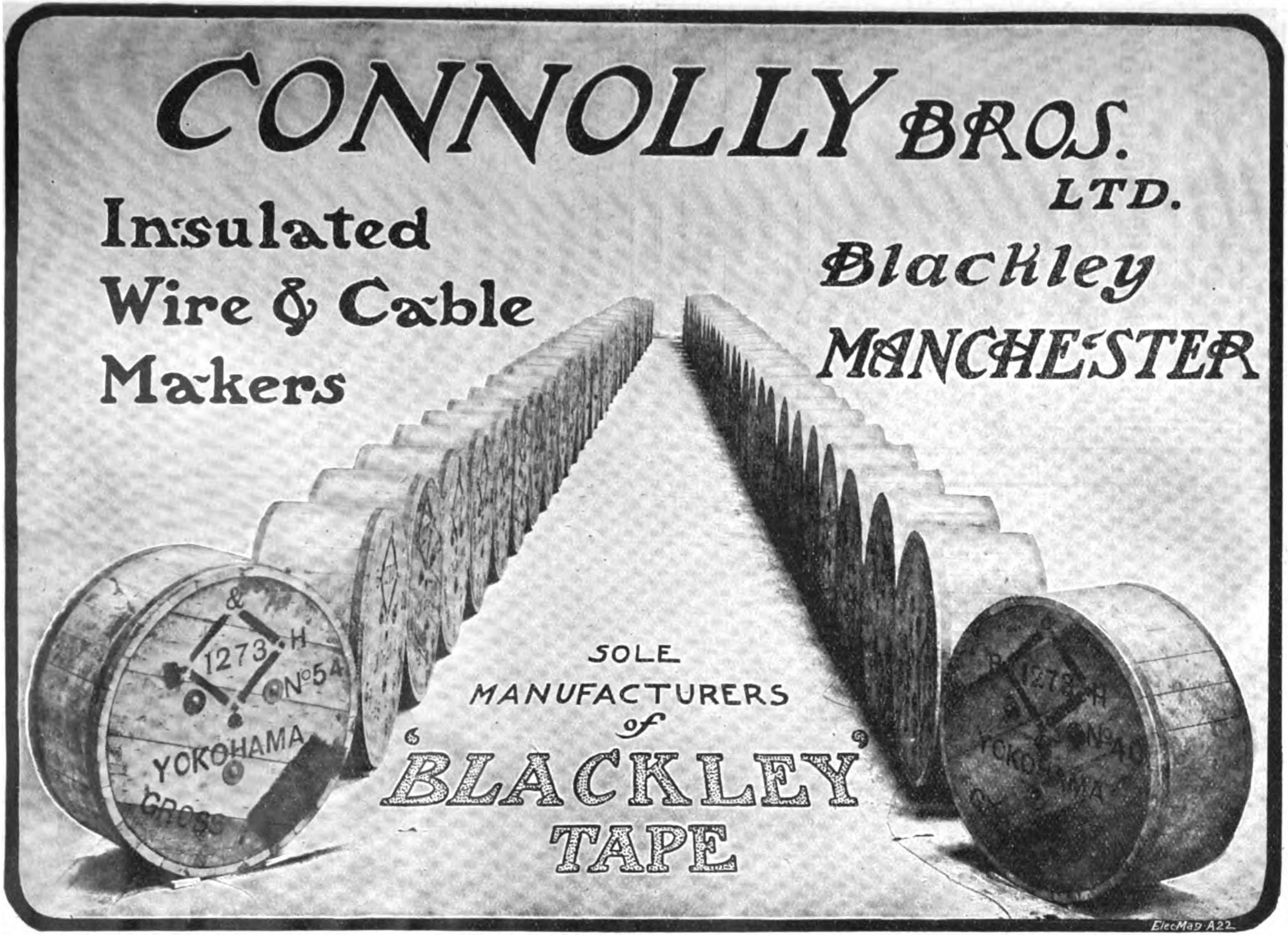

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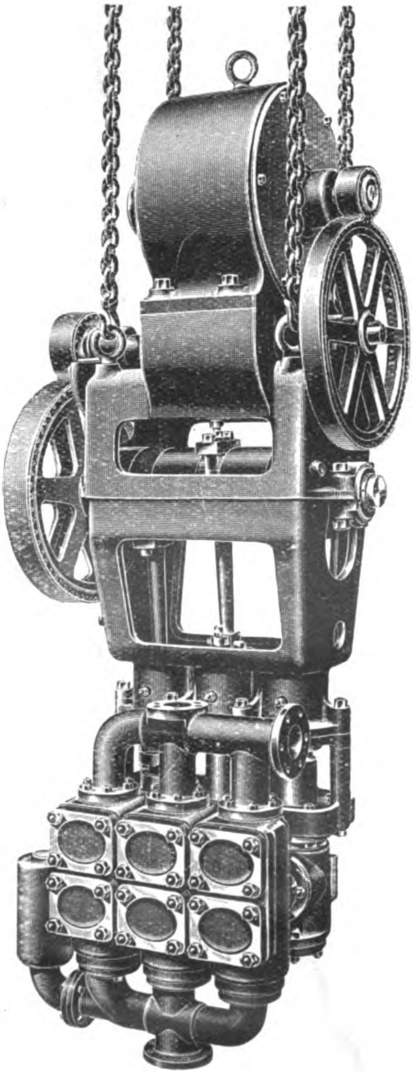

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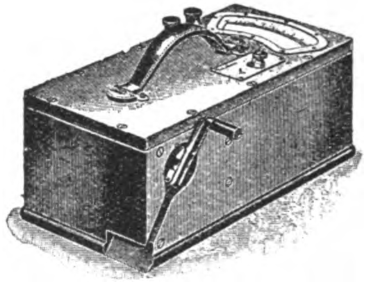

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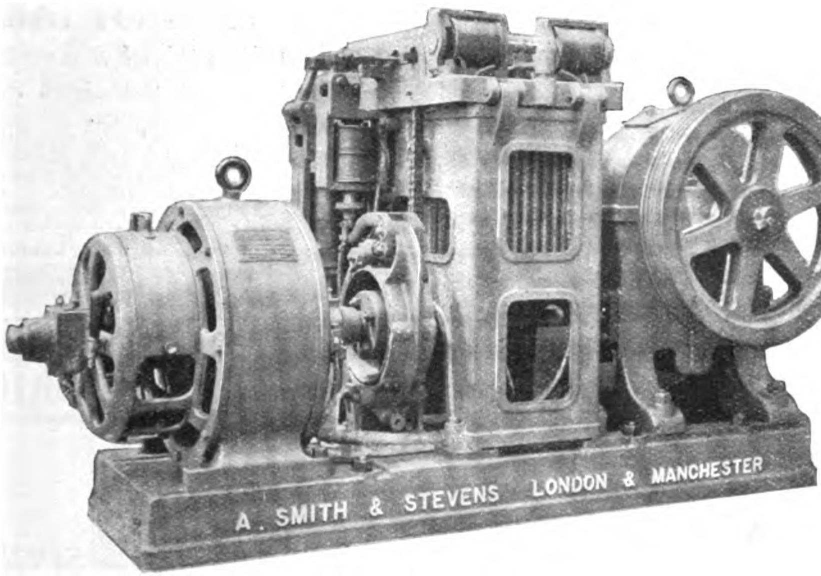

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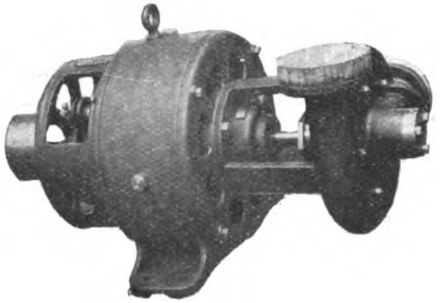

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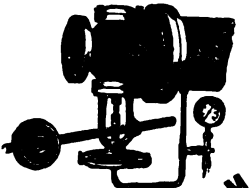

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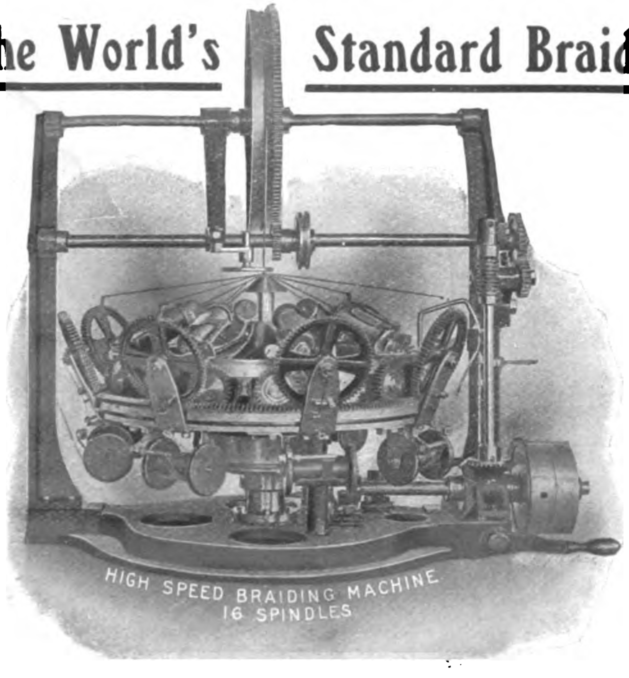

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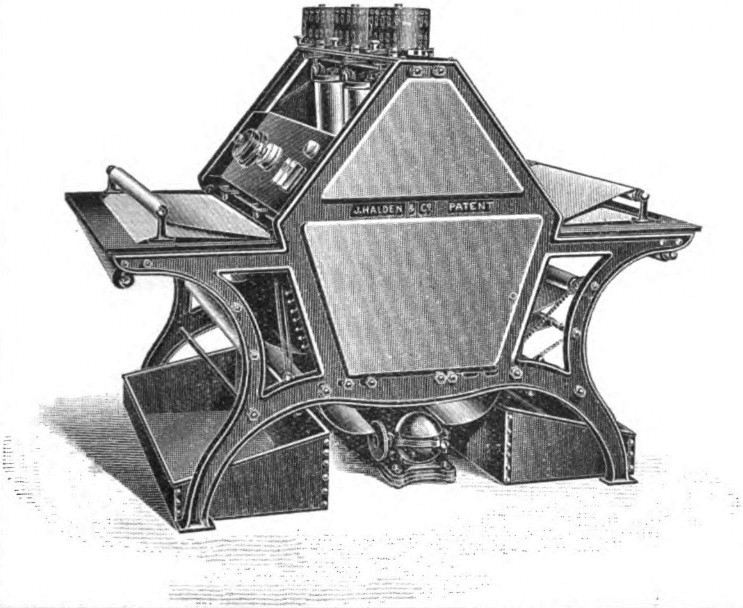

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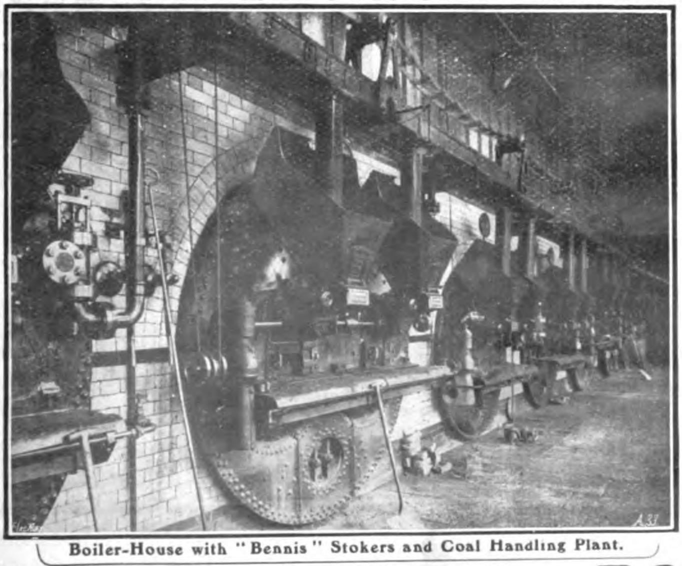

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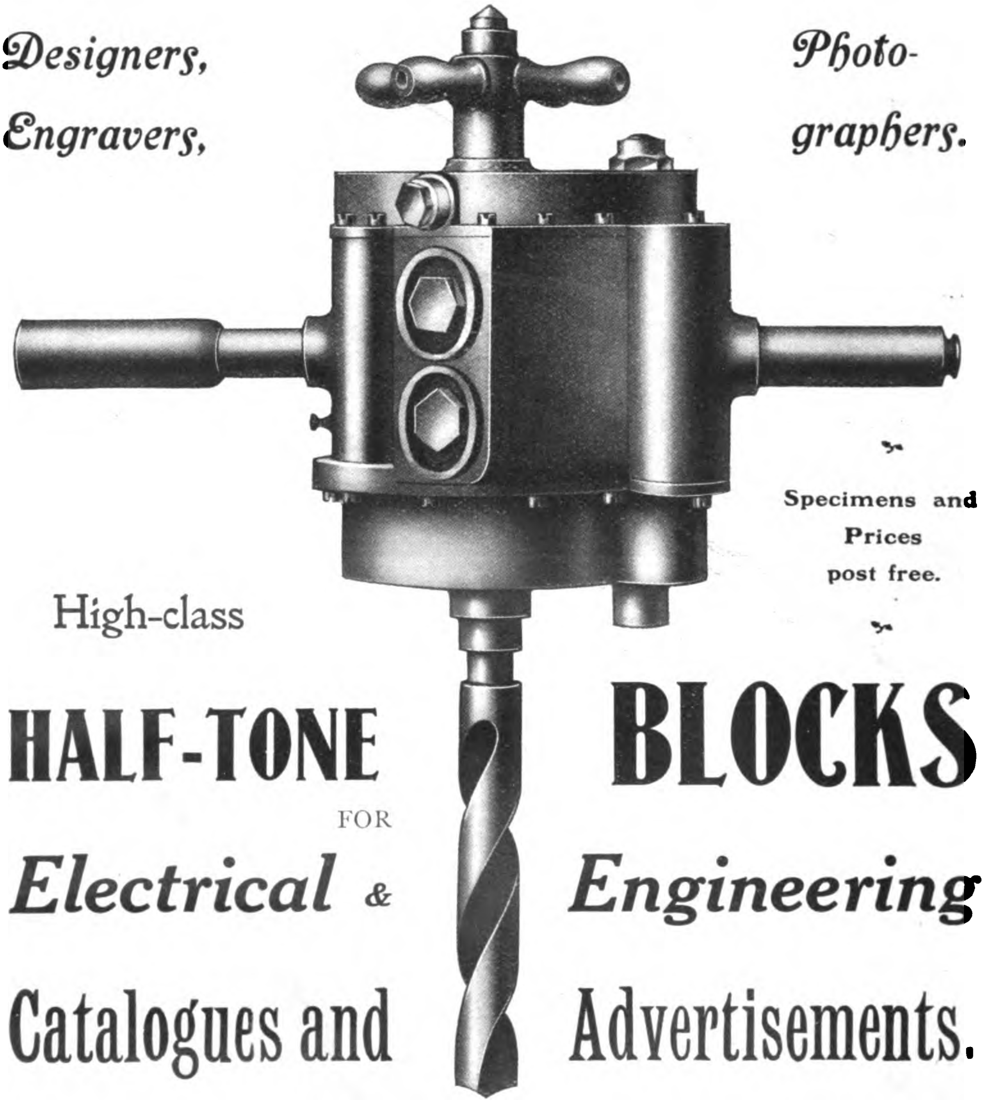

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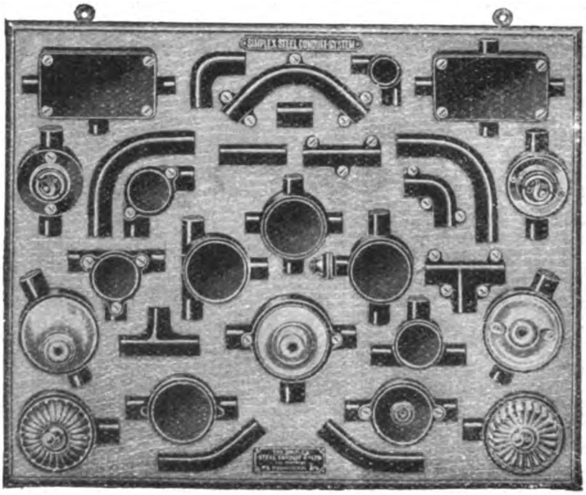

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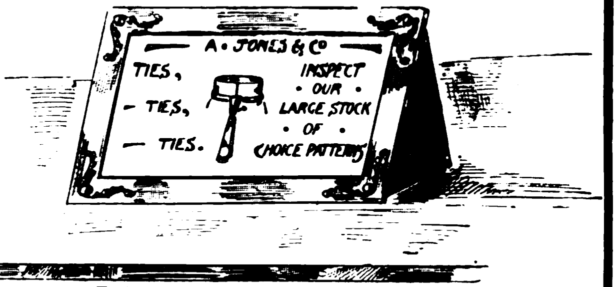

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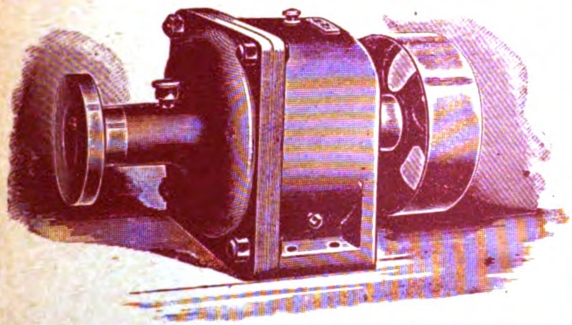

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……

Index to Advertisers.

For specialities and manufactures of firms below, see preceding Buyers' Guide.

	PAGE
A. E. G. Electrical Co. of South Africa, Ltd.	7
A. E. G. English Manufacturing Co., Ltd.	15
Adams Manufacturing Co., Ltd.	
Angus, George, & Co., Ltd.	
Armorduct Manufacturing Co., Ltd.	
Automatic Standard Screw Co.	ii. of cover
Babcock & Wilcox, Ltd.	6
Bateman's Machine Tool Co., Ltd	
Bayliss, Jones & Bayliss, Ltd.	
Bennis, Ed., & Co., Ltd.	
British Electric Plant Co., Ltd.	
British Steam Specialties, Ltd.	27
British Westinghouse Electric & Mfg. Co., Ltd.	
Broadbent, Thos., & Sons, Ltd.	
Campbell Gas Engine Co., Ltd.	
Clarke, Chapman & Co., Ltd.	6
Connolly Brothers, Ltd.	13
Craven Bros., Ltd.	
Crompton & Co., Ltd.	5
Crypto Electrical Co.	
Cundall, Sons & Co., Ltd.	
"Cyclopædia of Applied Electricity"	21
Diesel Engine Co., Ltd.	10
Edwards Air Pump Syndicate, Ltd.	
Electric & Ordnance Accessories Co., Ltd.	26
Electrical Standardizing, Testing & Training Institution	iii. of cover
Electromotors, Ltd.	
Ferranti, Ltd.	
General Electric Co., Ltd.	
Glaholm & Robson, Ltd.	
Green, E., & Son, Ltd.	16
Halden, J., & Co.	28
Hall, B. J., & Co., Ltd.	
Hardy Patent Pick Co., Ltd.	ii of cover
Hendry, James	iii of cover
High Speed Braiding Machine Co., Ltd.	26
Holmes, J. H., & Co.	
Holroyd, John, & Co., Ltd.	
Hornsby, Richard & Sons, Ltd.	9
Hulse & Co., Ltd.	
Hyatt Roller Bearing Co.	

Index to Advertisers—*continued.*

PAGE
India-Rubber, Gutta-Percha, & Tel. Wks. Co., Ltd. 11
Industrial Engineering and Motor Co., Ltd. . 3
Kuettner, Macdonell & Cookson, Ltd. . .
Lancaster & Tonge, Ltd. . . . . . .
London & County Printing Works 24
Longmans, Green & Co. 20
Macintyre, James, & Co., Ltd. . . . . .
McGeoch, Wm. & Co., Ltd. 25
Meldrum Bros, Ltd. . . . .
"Modern Electric Practice" . . . . .
"Modern Engines and Power Generators" . .
Morris-Hawkins Electrical Co., Ltd. . . .
Mountain & Gibson, Ltd. 8
Nalder Bros. & Thompson, Ltd. . . . 8
Newton Bros. 27
North-Western Electrical Appliance Co. . . 25
Pearn, Frank, & Co., Ltd. . . . . . iv. of cover
Phillips, Charles D. 30
Phœnix Dynamo Manufacturing Co., Ltd. . .
"Practical Coal-Mining" 19
Press Etching Co. 29
Pritchetts & Gold, Ltd. . . . . . .
Reason Manufacturing Co., Ltd. 2
Rhodes Electrical Manufacturing Co., Ltd.. .
PAGE
Ross, R. G., & Son . . . . . . iii. of cover
Santoni, D., & Co. (1906), Ltd.
Selig, Sonnenthal & Co. . . . . . .
Simplex Conduits, Ltd. 30
Smith (A.) and Stevens. . . . . .
Sprowson, William, & Co. . . . . .
"Standard Wiring" 22
Stirk, John, & Sons . . . .
Stolzenberg Patent File Co. 11
Sun Electrical Co., Ltd. . . . . . .
Suter, Frank, & Co., Ltd. 14
Temperley Transporter Co. . . . . .
Thames Ironworks, Shipbuilding and Engineering Co., Ltd. . . . . .
Thom, John G. 12
Trading and Manufacturing Co., Ltd. . . .
Turnbull, Alex., & Co., Ltd. 16
Union Electric Co., Ltd. 27
United States Metallic Packing Co., Ltd. . iv. of cover
Waygood, R., & Co., Ltd. . . . . .
White, J. G., & Co., Ltd. . . . . .
Wild, M. B., & Co., Ltd. 28
Winn, Charles, & Co.. . . . . . .
"The World of To-day" . . . . . .
"World's Work" 22

LITERARY CONTENTS of this Issue of

The ELECTRICAL MAGAZINE.

PAGES
The World's Electric Progress . . . 59-62
Electric Power in Collieries 59
Engineering Fashions 59
Illuminating Engineering 60-61
Large Gas Engines 61
The New Lamp Situation 61-62
Individualism and Efficiency . . . 62
Power 63-68
Large Gas Power Plants. C. E. Douglas . 63-68
Traction and Transport 69-75
Rectifier for Electric Locomotives . . . 69-72
Tractive Effort of the Single-phase Commutator Motor. B. G. Bergman . . . 73-75
Operating Costs of Electric Mining Locomotives 75
Central Station Practice 76-82
Central Station Supply Economics. A. M. Taylor 76-81
Modern Switchboard Devices. C. W. Stone. 81-82
Lighting and Heating 83-86
The Helion Filament Incandescent Lamp. H. C. Parker, W. G. Clark . . . 83-86
Saw Annealing by Electric Arc. L. L. Arnold. 86
Cooper Hewitt Lamps in a Steam Room . 86
Telegraphy and Telephony 87-89
A New System of Telegraphy . . . 87-88
Sustained Electrical Oscillations . . . 88-89
Strength of Wooden Poles 89
Electrical Design and Manufacture . . 90-94
Estimation of Armature Diameter. L. A. Freudenberger 90-92
PAGES
Method of Drying-Out Plant. S. L. Sinclair, E. D. Tyree 92
The Treating of Transformer Oil. S. M. Kintner 93-94
Electro-Chemistry, Electro-Physics, and Electro-Metallurgy 95-97
The Standard Cell. F. A. Wolff, C. E. Waters 95-97
Development in the Electrical Manufacture of Steel 97
Students' Section 98-100
Canada as a Field for the Electrical Engineer. C. F. Gray 98
Three-Phase Power Measurement. H. M. Scheibe 99
Dynamos in Parallel 99-100
Wiremen's Section 101-102
Wiring Work in Completed Fireproof Buildings. T. W. Poppe 101-102
Manufacturing Progress . 103-110
Engineering Export Trade 103-104
The Engineering and Machinery Exhibition, London, 1907 105
Time Lag Safety Device 106-108
A Large Three-Phase Automatic Damper Regulator and a Large Lift Controller . . 108-109
Motor-car Specialities 109-110
Trade Notices 110
Literary Section . . . . 111-116 & 17-23
Reviews of Books 111-114
New Catalogues 114-115
The World's Electrical Literature . . . 116
Practical Books 17-23

You will find the List of Technical Books** (with particulars and prices) given in the Literary Section **invaluable to you.

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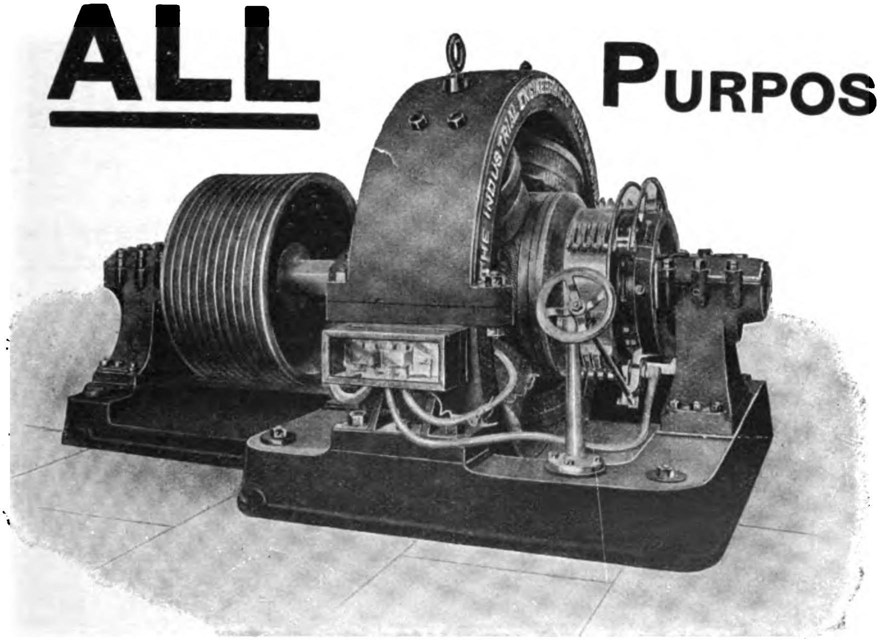

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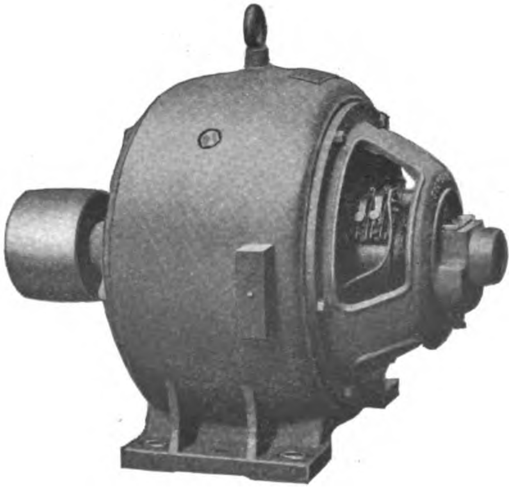

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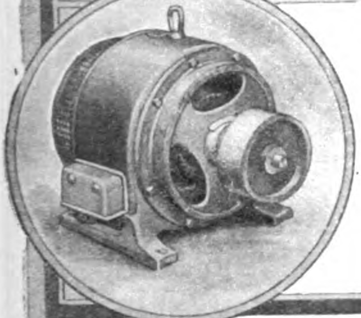

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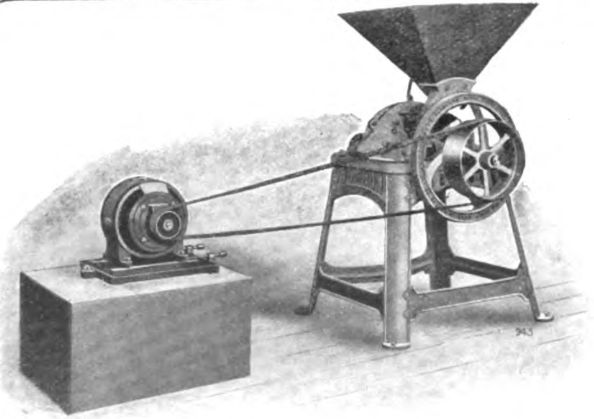

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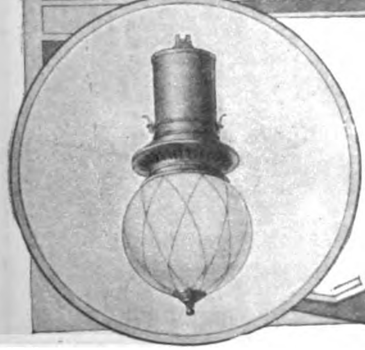

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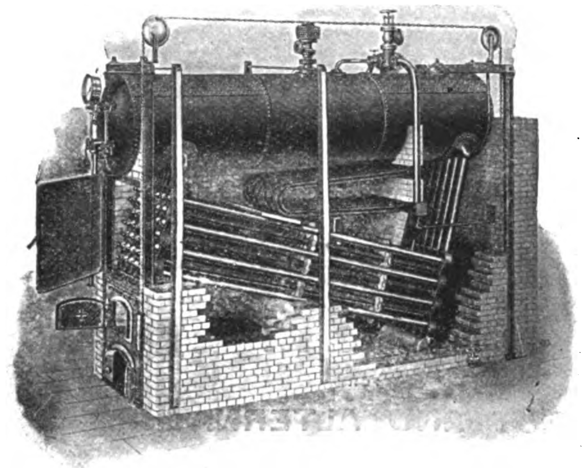

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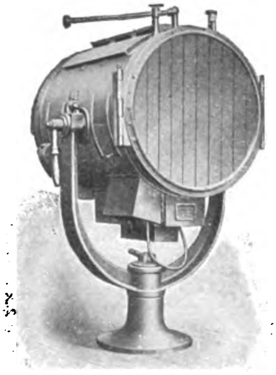

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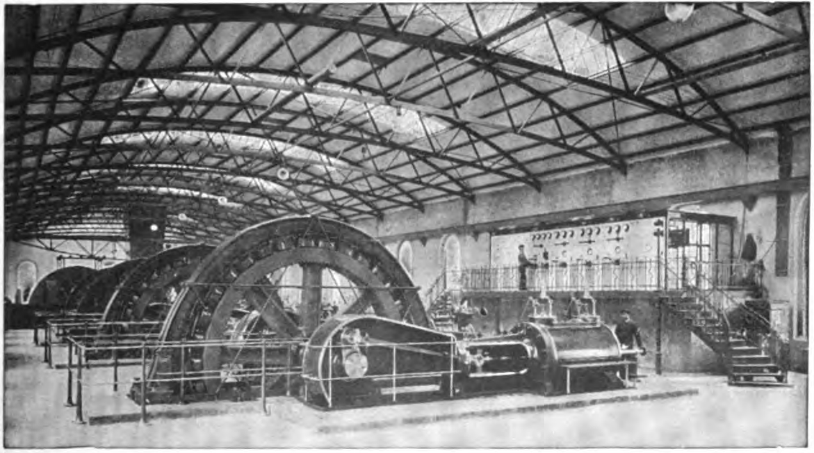

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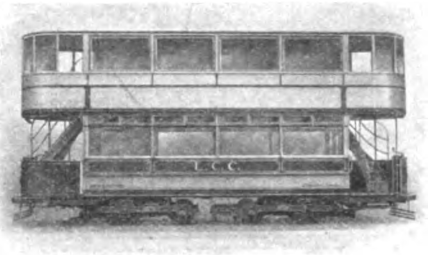

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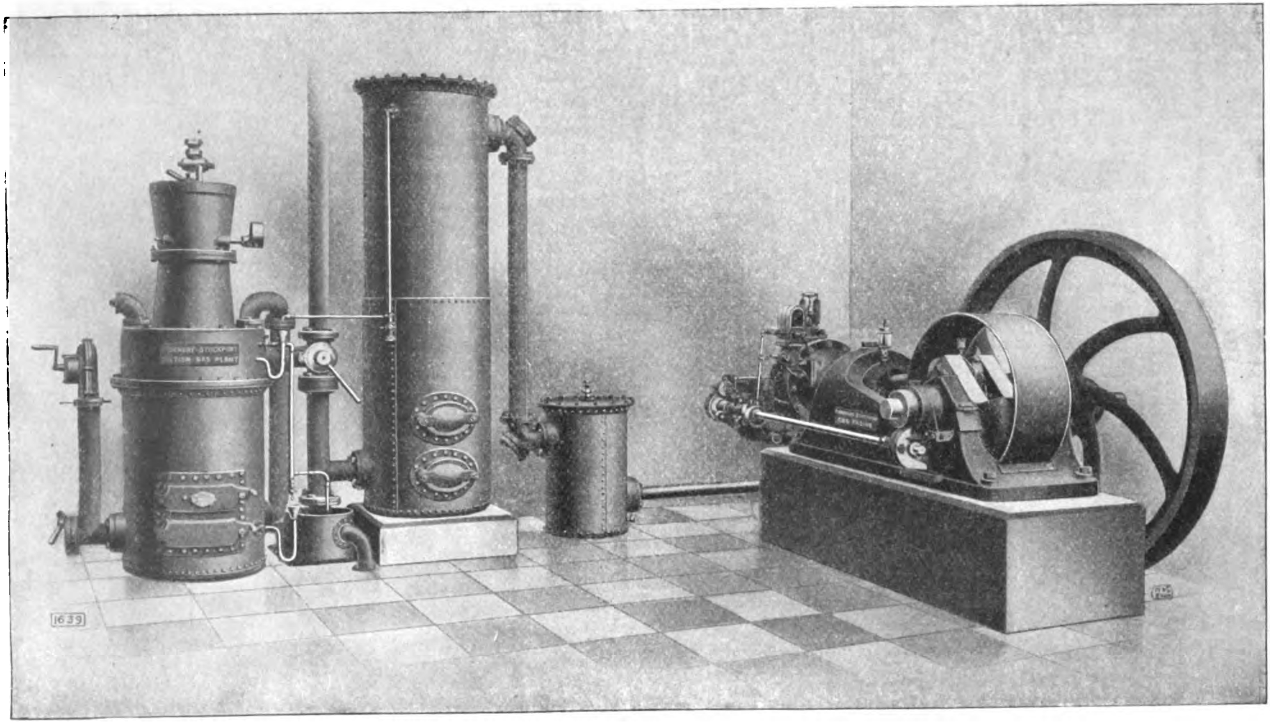

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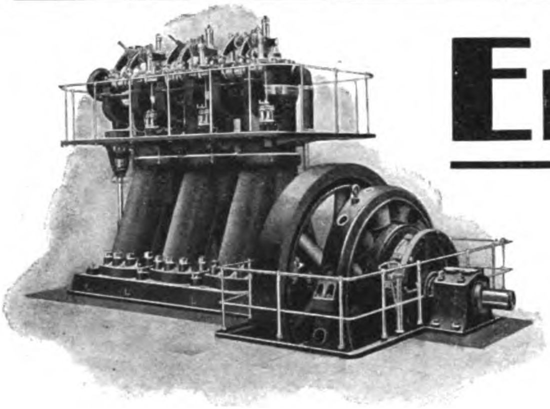

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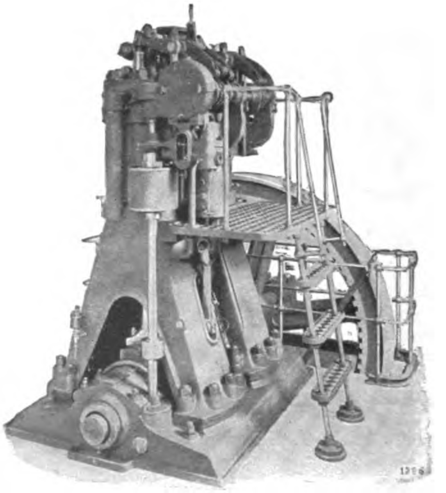

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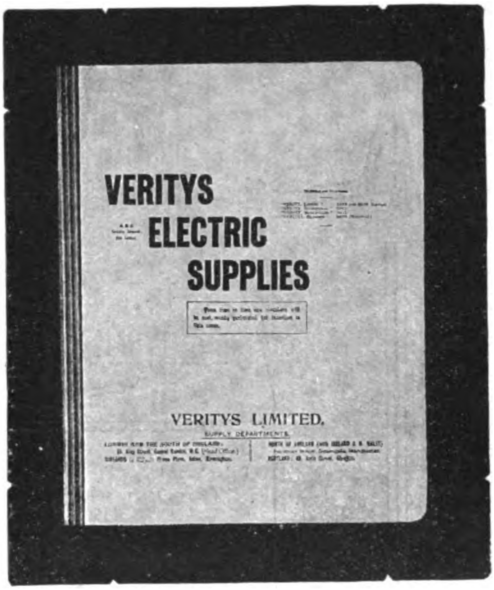

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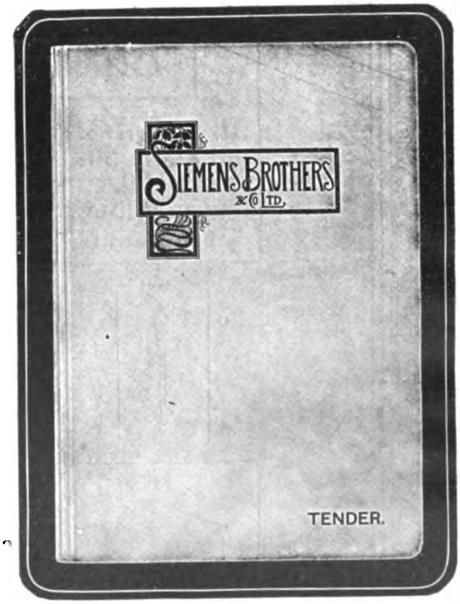

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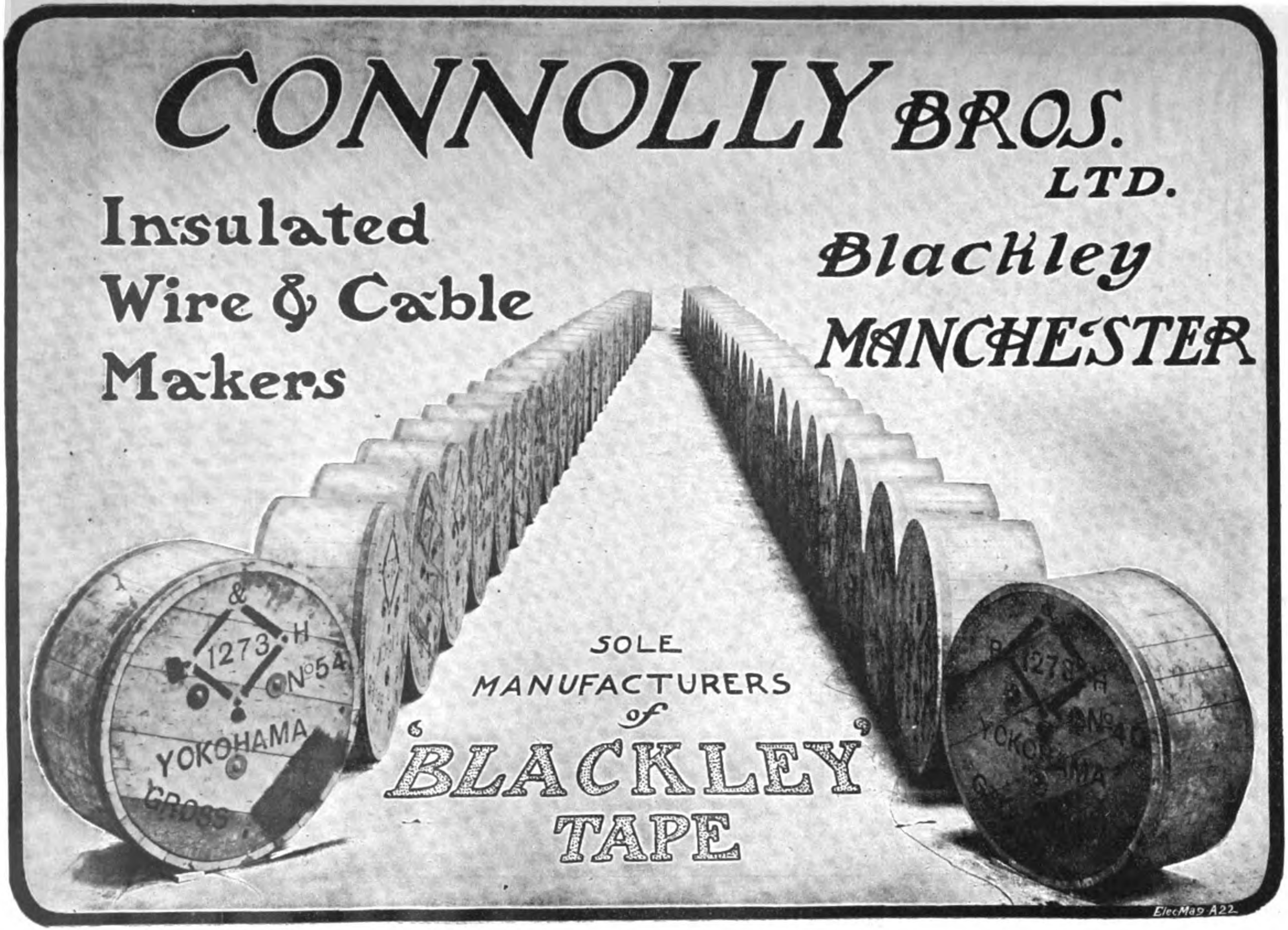

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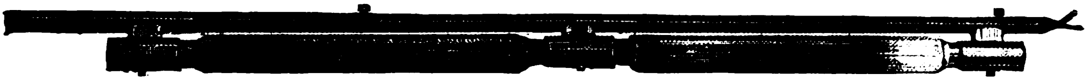

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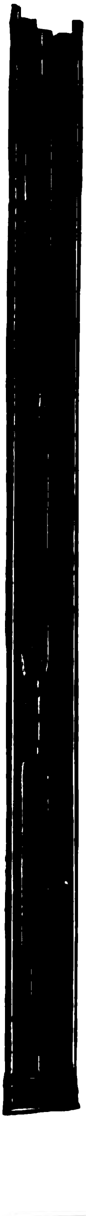

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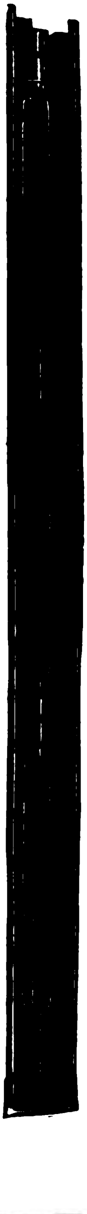

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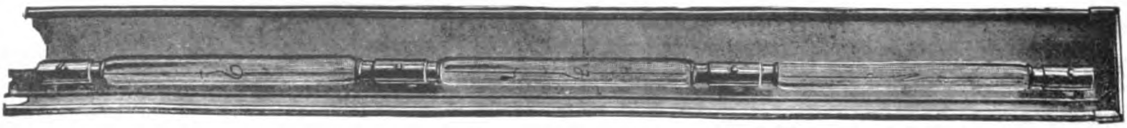

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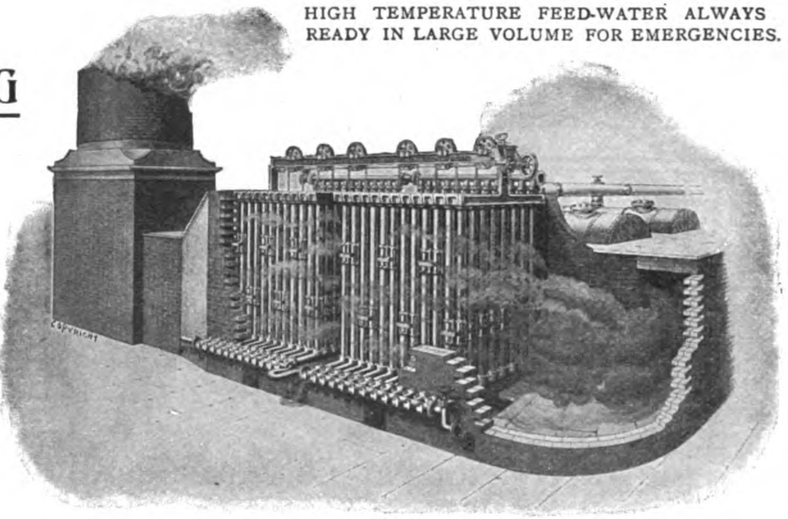

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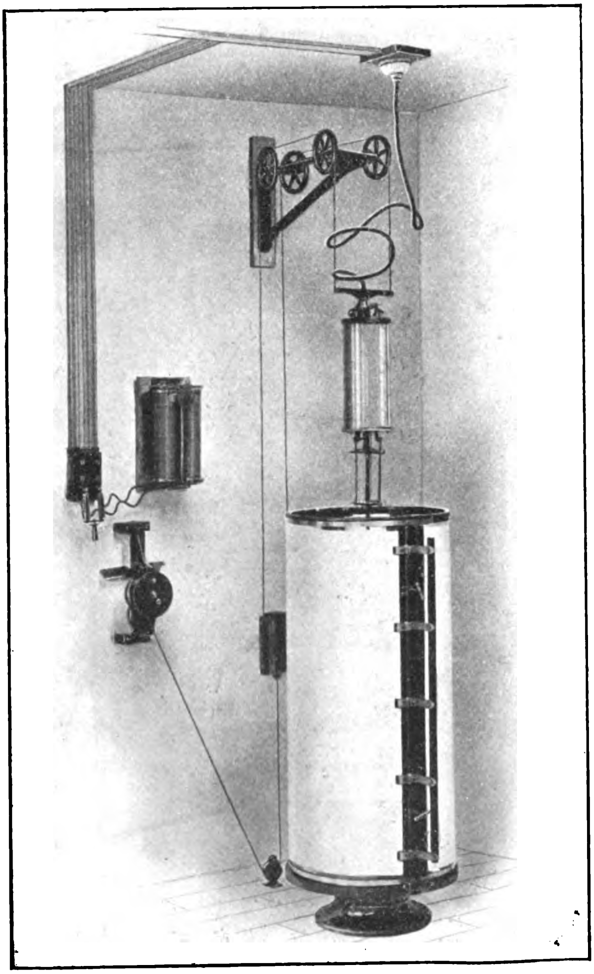

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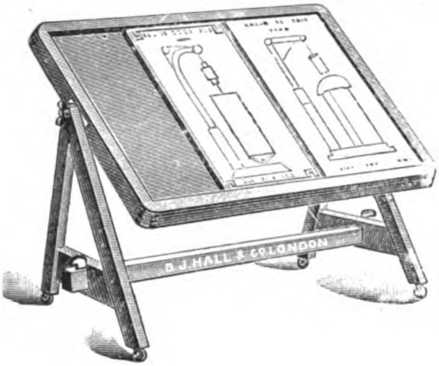

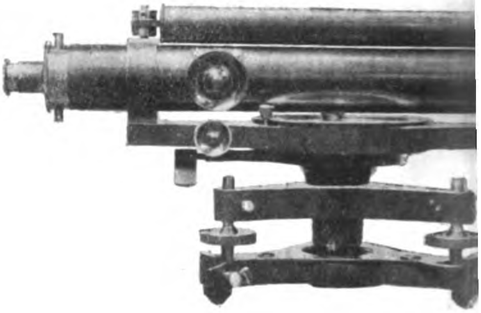

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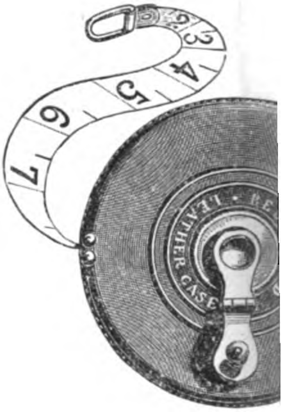

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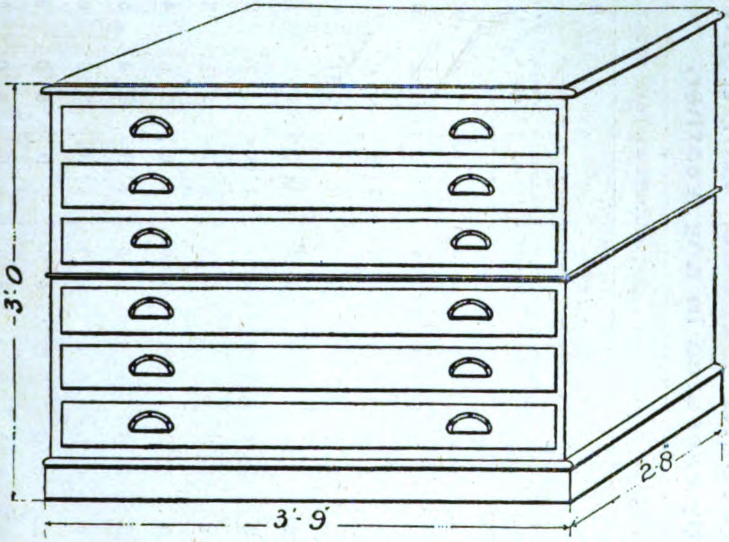

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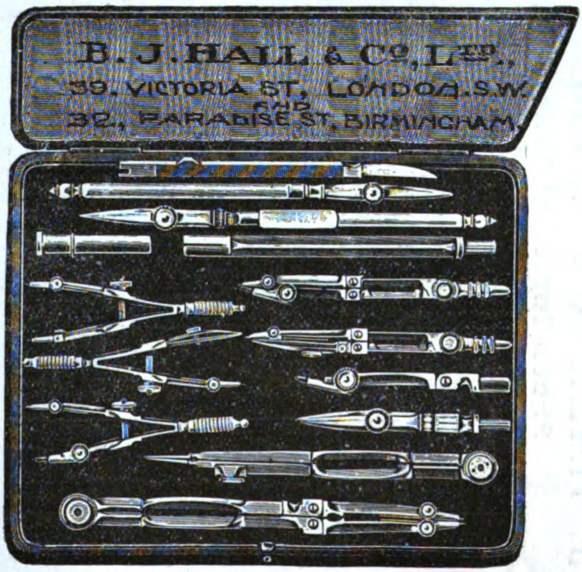

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The Electrical Magazine.

FOUNDED AND EDITED BY
THEO. FEILDEN.

Vol. VII. No. 2. (38th Issue.) London. February, 1907.

The World's Electric Progress.

Electric Power in Collieries.

As intimated in our last number, it is proposed to devote, from time to time, certain issues of The Electrical Magazine each to a specific branch of applied electricity. It will be our endeavour to make each and all of these special numbers as complete as possible and thoroughly up to date, so that the result in each case will be a valuable and practical work of reference for those who employ electric power as an adjunct in their respective industries, and also for those who are still to come into line with modern practice.

The first of this series will be devoted to Electric Power in Collieries and will form the March number of The Electrical Magazine. If there is one particular industry more than another in which the inherent advantages of electricity are seen to best advantage it is for underground power purposes in collieries. The ruling conditions of pit-work—widely separated power-requiring machinery, damp and dirt, restricted space, rough usage, lack of close supervision, and so on—are all adverse to the safe and economical performance of running machinery: such trying circumstances call essentially for electric power. No other form of power transmission or application can approach electricity for colliery service.

Whilst there has been a very steady development of electrical mining applications in this country, the progress made in this all-important industry is not so rapid as is merited by its great potentialities. In those mines where electricity has been introduced it has not only stayed but has very quickly led to the exclusion of all other forms of mechanical power from the pit workings. We in this country are not so advanced in the practice of electrical mining as are Germany and the United States. There is but one reason for our slowness in this direction, and it rests in the old, old story of British conservatism; coal-getting is essentially a national industry of this country, indeed it may be considered as one of the most potent factors in the making of our greatness. It has always been a trait of the national character to cling stubbornly to those methods by which our forefathers gained supremacy, and we are inclined to think that there is a good deal of this spirit ingrained in the leaders of our coal industry.

But time and the dictates of common sense will bring about changes in this as in other parallel national codes of practice. Already there are many of our largest collieries in which the underground plant is operated entirely by electric motors.

It is for the electrical man to see that the conversion of the remainder is effected quickly, to the enhanced safety of the underground workers and the profit of all.

As said, we are about to help in the development of this phase of applied electricity, and we hope to produce in the next issue of The Electrical Magazine a treatise on the subject which shall at once be a guide to the coal-master, a help to the electrical manufacturer, and a spur to the coal-electric industries of this country.

* * *

Engineering Fashions.

The engineering industry, including its electrical part, is generally considered as particularly one in which plain, matter-of-fact utility ranks as the dominant characteristic. Yet who can deny that even in this rigidly practical profession there is no blind following of fashion? A general view of business done in electrical matters reveals a very considerable amount of the follow-my-leader principle, and often as not this means real loss to the majority. In any case, where this spirit prevails, enterprise, judgment, and good business are not.

One expects to find this failing amongst the general non-engineering buyer of electrical goods; irrespective of nature of service a man must have a motor or a lamp like those of his neighbour—the electrical salesman will, or should, put this trouble to rights unless his client be beyond redemption. We are not concerned with that phase of engineering fashion, but with the more serious fault of unthinking imitation amongst electrical engineers: more serious because in this the fault is akin to a personal habit and is as difficult to cure.

This vogue is noticeable in public electrical supply matters. Has there not been a sacrifice made to fashion by many small boroughs and townships who would have an electricity works of their own on which to ultimately lose money rather than enter into an arrangement with a local company or neighbouring borough for the supply of current in bulk on a mutually profitable basis? It is furthermore fashionable in these matters to be extravagant: the works and office buildings must be of more solid proportions than a fortress and more elaborate than many a palace; the generating plant shall be turbo-alternators, although it may be a little compact town with no day load to speak of and set in the heart of a coalfield; and so on all along the line we see evidence of the cult of fashion.

The desire to go one better is praiseworthy indeed—but to embark on any enterprise of emulation having in mind only the joys and pleasure of possession without counting the pains and the cost is merely begotten of covetousness and envy—it is sheer folly, not enterprise.

There are examples of the disastrous rule of fashion in every phase of engineering as in all things; but none the less it is to be fought against, and there is room for very great improvement in this direction in electrical matters. As said, the cure rests with ourselves as individuals—before taking any actual step in developments let us be quite confident that we are in the real track of progress, that we are about to do that which is best and surest to attain the intended result, and that we are not merely followers of fashion.

❧

Illuminating Engineering.

THE great progress made in America towards the development of the art and practice of artificial illumination irrespective of the source or nature of lighting medium was forcibly indicated at the first annual meeting of the Illuminating Engineering Society held in New York on the 14th ult.

The President's report indicated how clearly the objects of the Society were being realised. The members' list includes such generally considered diverse industries as electrical and gas engineers; designers of globes, reflectors, and fittings; oculists, architects, physicists, and chemists; and those engaged in the manufacture and sale of all classes of lighting apparatus and materials.

DR. CLAYTON H. SHARP.
President of the Illuminating Engineering Society, U.S.A.

In this new profession there has already cropped up the universal and vexing question common to all industries—that of nomenclature and standardization. A committee of some thirteen members has been deputed to consider this subject. New officers for this year were appointed, with Dr. Clayton H. Sharp, the well-known principal of the New York Testing Laboratories, as President. The Society has been divided up into five local sections, and there is no doubt that illuminating engineering is now definitely established as a distinct and permanent profession. At least that is so in America.

During the course of the past year we several times had occasion to indicate in THE ELECTRICAL MAGAZINE the importance of this subject; perhaps this country will eventually have a Society of Illuminating Engineers, but in any case we can only repeat that a study of the science of illumination presents a real opportunity for many of the less technical electrical workers.

Take, for instance, the average wireman, who, as a rule, has few ambitions, mainly because he generally has the view that there is little or no scope for development in his line of business. Up to the present, wiring and installation work have been too much regarded as the training-ground for young electricians who exercise themselves on it for a brief period and with a sigh of relief hurry on to some other branch of the business. It seems that the dissatisfied wireman need no longer consider his position hopelessly restricted. There is no reason now why the ambitious young fellow should not enter upon wiring and installation work with the full intention of subsequently making it his business. Given the present higher goal for his ambition, the position of affairs is altered to an extent meriting the expenditure of time and money on a systematic course of training leading up to this object. The improvement is to be gained by including the study of illuminants and their disposition in the range of subjects entering into the wireman's training. An early and extensive experience in wiring work forms a most suitable foundation upon which the results of subsequent investigation and study in illuminating engineering can be effectively raised. The inclusion of the science and art of illumination in the field of practical wiring supplies the much-desired incentive to a class of electrical workers which has hitherto been quite unable to specialize in its own particular sphere. We cannot commend too strongly this new phase of electric lighting to our readers of the wiring and artisan classes.

* * *

Large Gas Engines.

THE paper by Mr. C. E. Douglas appearing in the Electric Power section of this number will be read with interest by all engineers because of its real practical worth. The question of steam *versus* gas power for electrical generation has been broached and discussed over and over again; there can be no doubt as to the ultimate victory of the gas-driven unit. Plain facts and absolute figures of work done with gas-electric systems are needed now. The author hits the right nail on the head when he declares that there is still some mistrust of gas-engines, and he disposes of this objection in a lucid, easily understood manner.

There is one great factor which has delayed large gas-engine development in this country. The manufacture of such engines does not appear to have yet been taken up in a full, whole-hearted, and energetic business spirit. Those few firms who do build really large gas engines are mostly builders also of steam engines and steam turbines, and whilst these last have remained in popular demand, the superior claims of the gas engine have not been presented in the commercial world with the force they merit.

Everybody knows of the high theoretical efficiency of the gas-driven engine; but only those who have had practice with the largest sized gas engine units know its every-day performance, and, to say the least, this is satisfactory. It is very certain that the large gas-engine only requires to be kept before the engineering fraternity with plain facts of actual results obtained and monetary benefits secured by its use, as Mr. Douglas has done in his paper; and, further, that the manufacturers shall be more forceful in advancing their products in the commercial sense, to bring large gas-driven electrical units into general use. The universal adoption of the gas-driven prime mover will do more towards the cheapening of electricity supply than any other possible development at present available.

* * *

The New-Lamp Situation.

HARDLY has the word "Osmium" become familiar to the electrical engineer than he is confronted with "Helion" as the name of the standard incandescent lamp elect. Are metallic filaments to be the order of the day after all? Osmium, tungsten, zirconium, &c., pure and in alloys, have opened up a wide field for the seeker after wealth and fame in the revolutionizing of electric lighting practice. The tantalum lamp has already faced the test of public opinion, and is scoring a great success. But are any of these "metallic" filament lamps, those still in the laboratory and those on the market, destined to sweep away the carbon filament glow-lamp? It would seem from the article which we publish in the Lighting and Heating Section of this number that the "Helion" lamp therein described may possibly cut short the career of metallic filament glow-lamps in their very earliest infancy.

A peculiar fact about the "Helion" lamp is that it is really an improved carbon filament lamp. An ordinary carbon strand is the basis of the filament, and on this are deposited minerals, notably silicon. Extremely high temperatures combine the constituents into a homogeneous filament having metallic characteristics; it is strong, perfectly elastic, and after fracture can be welded by heat. Lamps of this form have proved to give efficiencies as high as three-quarter watt per candle-power (in the paper read by Messrs. Parker and Clark before the American Physical Society one watt per candle was selected as sufficiently good for the purposes of the tests made!) There are indications that the lamps will be made of very long life. The most important point of all, which would seem to place the "Helion" lamp above all the highly efficient and long-burning metallic filament lamps, is that "Helion" lamps can be, and are, made for our present-day lighting pressures, that the lengths of the filaments are, voltage for voltage, not greater than those of standard carbon filament glow-lamps.

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Individualism and Efficiency.

THERE were words of wisdom in the able and candid after-dinner speeches of Mr. Hugo Hirst and Mr. Bevis Bevis as delivered on the evening of February 2nd, the occasion being the seventeenth annual gathering of the chief officials and business friends of the General Electric Company.

Mr. Hirst dealt fully with the electrical industry in its international sense, discussing the question as to why it is that a large electrical firm and also a large power company find it unable to make both ends meet when similar German firms can make large dividends. Tariff reform and patent reform entered into the question, but the most important, because unusually outspoken, phase touched upon was that of the ruling labour conditions in this country. The growing and now very considerable political value of trade-unionism is a matter of serious import to the manufacturer. There can be no doubt that the co-operation of workers is to be commended in very many ways, and the various unions have accomplished many great and good reforms. But, as Mr. Hirst pointed out, there is still connected with these organizations the objectionable and business-destroying feature of neglect of the individualism of the worker. Who can deny that there is a gradation of labour?—surely there are good workmen and bad. It does not need any very great study to realize beyond all doubt that this is harmful to business progress in the national collective sense as well as to every worker. The inventive faculties and enterprise of the man, even more than those of the master, are fettered. This factor of neglect of the individual in the artizan class has more to do with the crippling of this country's industry than is generally realized. There would seem to be no insurmountable reason why trade-unions should not introduce and foster the spirit of securing for their members wages in proportion to the individual quantity and quality of work done. Let them effect this grand reform and we shall soon find a vast improvement in Britain's inventive progress and in her general industrial condition.

If individualism is necessary for artizans and the working classes, it is also essential for the master. Is it not, indeed, this very personal factor or individuality which differentiates the master from the men? Of course this is denied, but not with the same emphasis as of yore. Mr. Hirst indicated that co-operative manufacturing is on the decline; no further proof is needed as to individuality or a personal supremacy of training and experience, together with—shall we say?—an inborn gift, being as essential in the leaders of industry as it is in all phases of life.

Mr. Bevis adopted "efficiency" as his text, emphasizing the importance of departmental efficiency in large concerns where the success of the whole depends absolutely upon every department's work, as each department is dependent upon the real worth of each individual member.

POWER: and its application to INDUSTRY

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Power, its Generation, Transmission, and Distribution.

*Large Gas Power Plants.**

C. E. DOUGLAS.

THE three principal prime movers available in this country for powers of 200b.h.p. and over are the reciprocating steam engine, the gas engine, and the steam turbine. With the increasing adoption of electrical driving for the majority of industries, the low-speed steam engine is gradually being displaced, and, on the other hand, the scope of its high-speed rival is limited by the universal adoption of the steam turbine, especially for outputs of 1500b.h.p. and over. The author is of the opinion that even the most sanguine of gas engine builders prefers to limit the maximum size of his unit to somewhere in the neighbourhood of this output, viz., 1500b.h.p., although larger units are in operation. Except in the case of large power supply companies, city corporations, and a few isolated instances of large manufacturing works, the ordinary industrial unit ranges from, say, 200 to 1500b.h.p., and therefore it is with the suitability or otherwise of gas plant for such installations that this paper deals.

The most weighty consideration which determines the adoption of one or other form of prime mover is reliability, combined with low cost of operation. No one dreams of questioning the reliability of the reciprocating steam engine; but is the cost of operation a minimum? There is an impression abroad that steam turbines are not so reliable as reciprocating steam engines. This impression may be unfounded, but the cost of turbine operation, in medium powers at any rate, is not less than that of high-class steam engines (see curves, Fig. 1). What prime mover, therefore, is available to give power at a lower cost of operation? The gas engine is the only one which meets this demand. The critic will at once raise the question of reliability, but the author will endeavour to prove that, for industrial purposes, the gas engine, along with its supply plant, is at least sufficiently reliable to warrant a much extended sphere of operation, and that it can be operated with greater economy than any other form of power plant, at least within the limits stated.

It is an unfortunate but incontrovertible fact that the majority of power producers and users in this country are of opinion that the large gas engine is still in an experimental stage. The fact—and fact it is—that on the Continent large gas engines aggregating literally hundreds of thousands of horse power are installed and in constant daily use, seems to leave the majority of British power users unmoved. It is perfectly true that a large majority of big gas engines on the Continent are working on waste gases from blast furnaces, but this is simply a matter of local conditions and convenience, and there is neither reason in nor proof of the assumption that a large engine is more reliable working with blast furnace gas than with producer gas. It is true that there is often considerable difference between these gases as to chemical and physical constitution, and blast furnace gas is usually weaker than average producer gas in the proportion of, say, 90 to 145b.t.u. per cubic foot.

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* Abstract of paper read Jan. 22, 1907, before the Manchester Section of the I.E.E.

On the other hand, there have been working in this country for long periods engines of several hundred horse power in one unit on waste gases from coke ovens, where the calorific value is often over 400b.t.u. per cubic foot, and engines of 1500b.h.p. are being installed at the present time to work on such gas. The London County Council are installing several large engines of about 250b.h.p. to work on town's gas having a probable value of 500 to 600b.t.u., and in America there are instances of large engines running for long periods on natural gas, having a value of 1000b.t.u. per cubic foot.

Citing these cases shows that the value of the gas has nothing whatever to do with the satisfactory operation of the engine, provided, of course, that the value in any installation remains reasonably constant, that the engine is designed to suit the gas, and that the gas is suitably cleaned before admission to the engine. If successful and far-seeing firms like Krupp, who had one gas power station of some 12,000b.h.p. in constant operation, decided only a year ago to instal two further units each of 1600b.h.p., and like the Gutehoffnungshütte, who have year by year increased their gas engine plant to some 10,000 b. h. p. capacity; and if other large manufacturing concerns have done likewise, surely the case for the reliability of the gas engine is proved. If it is reliable abroad, what conditions either of manufacture, installation, or operation militate against its success at home? There is no question but that large gas engine builders have now learned in many cases through sad experience; but if experience is a hard master, the lesson may be well learnt with profit both to the builder and to the user. This state has been attained, and the installation of large gas engines and plant has definitely passed out of the experimental into the commercially profitable stage; there are numerous and authentic cases of large gas engines operating night and day continuously over long periods, with absolutely the same degree of steadiness and reliability as a steam engine.

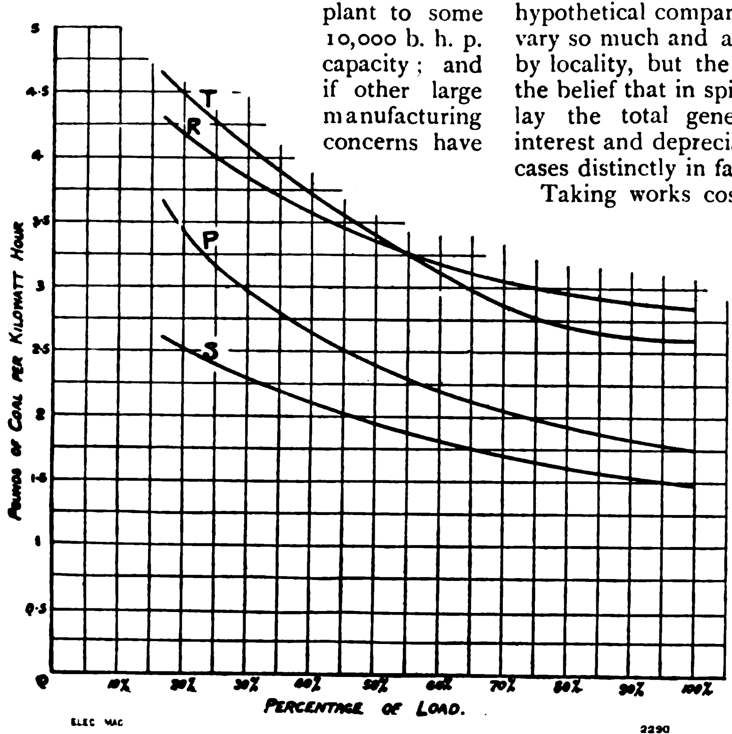


FIG. 1.

Turning to the question of economy of operation, it is not sufficient to consider merely the usual station or working costs; we must also take into account interest and depreciation on capital outlay, because in most cases of large gas power plant this is somewhat greater than the outlay involved by a new steam station of equal capacity.

It is, perhaps, difficult to make a direct hypothetical comparison, because conditions vary so much and are so largely influenced by locality, but the author is confirmed in the belief that in spite of higher capital outlay the total generating costs, including interest and depreciation, work out in most cases distinctly in favour of the gas station.

Taking works costs alone, and assuming that we have proved the reliability of the gas plant, the items for wages, running stores, repairs, and maintenance differ little in the two cases: on the other hand even the most inveterate critic of the gas engine cannot deny its marked superiority as a heat engine over the steam engine. This means a substantial diminution of the heaviest item in works costs, *i.e.*, the fuel bill. There is a further saving in that the stand-by losses in the case of gas are really very much less than in the case of steam; this has been proved over and over again. A gas producer only requires about one-twentieth of the fuel that is necessary in the steam boiler for banking fires overnight or during periods of light load. Mr. Dowson, in his recent book on "Producer Gas," has shown that on a 500b.h.p. steam plant the stand-by losses have been assessed at 15 per cent. of the total fuel consumed in twenty-four hours, while the stand-by losses in a gas plant of equal capacity only amounted to 2 per cent. of the total coal consumed. These figures are substantiated by numerous other tests. In the case of municipal stations with a relatively low load factor, this point is of the utmost importance. Instead of having the continual and serious loss due to the condensation of steam in pipe ranges, we have the beneficial cooling of gas tending to increased efficiency and cleanliness. It is frequently stated that the heat efficiency of the gas engine on low loads is bad compared with the heat efficiency of the steam engine under similar loads. The curves shown in Fig. 1 give the comparison between the two, the figures in each case being based on actual results and not on assumption. We have therefore two factors making for economy with gas, first the actually lower fuel consumption per unit generated on continuous load (whether full or otherwise), and the substantial reduction in stand-by losses.

The table below gives the published working cost of ten large municipal stations, and a diagram (Fig. 2) has been made from the averages of these showing that fuel alone amounts to half the total working costs. It is precisely this item which can be so substantially reduced with gas plant.

As to capital cost, a close examination of completed and carefully projected installations generally shows that if a new steam station is to be installed on the most economical lines, and is equipped with coal handling plant, economisers, feed heaters, superheaters, possibly water purification plant, oil separators, and surface condensers, the total cost of the installation, including buildings, foundations, and chimney, is not far short of the cost of installing gas. It is not necessary to provide a house for the gas producing and cleaning plant, except in so far as it may be necessary to erect a corrugated iron screen or roof to shelter the men when they have to work on top of the producers. In the evidence before the Royal Commission on Coal Supplies, it was stated that the complete large power gas installation might cost some ten per cent. more than a complete and highly efficient steam plant of equal capacity; this estimate was based on actual installation figures. As a matter of fact the author has authentic figures from which it appears that the total cost of some gas engine installations is actually less than that of steam plant, each complete in every respect.

While gas plant can be installed to drive electrically or direct, in most cases it will be obvious that locality and existing conditions govern to a large extent a decision as to the installation. For large powers it is only in rare cases of special convenience—and

Name of Borough.	Type of Engines.	No. of Units sold per annum.	Cost in Pence per Unit Sold.					Load Factor. $\frac{\text{Units} \times 100.}{\text{Max. L.} \times \text{Hrs.}}$
			Coal and other Fuel.	Oil, Waste, and Stores	Wages.	Repairs & Maintenance.	Total Works Cost.	
Liverpool......	Reciprocating	31,452,323	.27	.04	.11	.08	.50	22.7
Bradford	,,	13,733,651	.23	.04	.07	.27	.61	24.5
Edinburgh	,,	12,914,119	.28	.04	.06	.16	.54	16.8
Leeds	,,	9,197,259	.18	.02	.09	.19	.48	15.6
Bolton	,,	6,055,551	.26	.04	.10	.11	.51	21.4
Blackburn	,,	3,331,460	.30	.08	.17	.09	.64	16.75
Coventry	,,	2,522,100	.27	.02	.13	.16	.58	18.7
Bootle	,,	2,292,974	.25	.03	.15	.14	.57	21.25
Dudley........	,,	1,611,500	.37	.08	.10	.08	.63	13.5
Govan	,,	1,602,606	.24	.05	.16	.12	.57	16.4
		Average..	0.265	0.044	0.114	0.140	.56	

AVERAGE WORKS COST PER UNIT SOLD IN ELECTRICITY WORKS (LIGHTING LOAD).

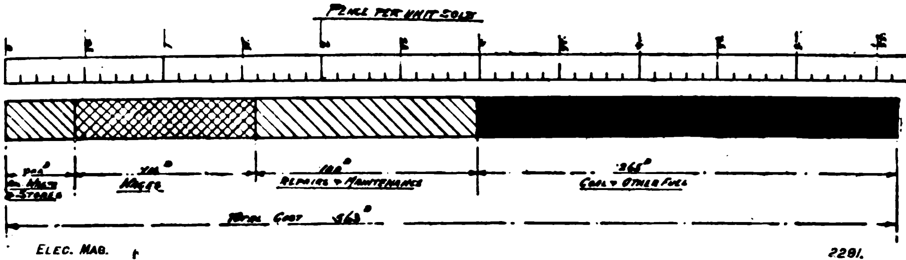


Fig. 2.

generally these are municipal—that town's gas can be used, on account of the relatively high cost of the same compared with producer gas; the former would require to be delivered to the consumer at a figure well below 1s. per 1000 cubic feet, to compare with the cost of the latter.

We, in the British Isles, are the fortunate possessors of large supplies of excellent coal for power gas purposes; and whether that coal be anthracitic or bituminous (provided that, if the latter, it be a non-caking variety) there are now many excellent producers, or generators, as they are sometimes called, which will efficiently gasify such coal. In Scotland and in the North and Midlands of England, many non-caking coals are available; and as far as calorific value is concerned, the resultant gas is reasonably uniform, ranging, under certain conditions of operation, from 130 to 170b.t.u. per cubic foot, by calorimeter. Some of the coals are exceedingly soft, with the result that much tar is produced and extra cleaning plant must be installed to cope with it. Caking or coking coal is inadmissible, because, though its gas-producing qualities may be as good as those of non-caking coal, it is physically impossible to work it, as the coal forms a sticky mass which chokes the producer. Coke is also, in many cases, applicable for producer purposes; but modern gas-works coke is often insufficiently carbonised, with the result that as much tar is produced as though soft bituminous coal were used. Anthracite is an ideal fuel to use; but excepting where it can be obtained in reasonable proximity to the site of the plant, as, for instance, in the South and South-West of England and Wales, its cost generally precludes its use, except for small plant. The amount of tar produced and consequently the extent and cost of the gas-purifying plant required, is a minimum.

On the Continent and also in America, briquettes, lignite, peat, wood, and charcoal are all employed successfully; and in most of our Colonies, as well as in the far continents, coal suitable for producer purposes is now being worked. Regarding the producers themselves, these are classified according to whether the air and steam required for the formation of the gas are *drawn* through the bed of the fuel by the action of the engine, or whether they are *forced* through by an independent blower; thus we get the suction and the pressure producer respectively.

It will be seen that the coal supply available is practically the first consideration; and that the higher the price of coal the greater the saving to be effected by gas. In one works near London the proprietors of a mill burned anthracite (costing about 20s. per ton) under their boilers, in order to prevent smoke nuisance in a densely-populated district; they installed a gas engine of 500b.h.p. to replace their steam engine, and a producer plant to gasify bituminous coal was put in. In this case, in addition to, let us say, at least halving the amount of coal formerly used by the steam plant, the price of the coal per ton was practically halved as well, so that the original fuel bill is now reduced by about 75 per cent.

Another point which is of great importance is the question of water supply. The water consumption of gas is much below that of steam plant; taking irrecoverable water alone—*i.e.*, that used for raising steam—in the first place to generate gas, and in the second to supply steam engines, about 1½lb. of steam are required per h.p.-hour with gas engines, while we can safely take 15lb. of steam per h.p.-hour as being required for condensing steam engines. For auxiliary purposes the amount of water required varies in both cases. In a paper read before the Institution of Engineers and Shipbuilders in Scotland on the 20th November last year, Mr. Hugh Campbell stated that for suction gas installations, the total quantity of water required, both for raising steam and purifying gas, is from 1½ to 2 gallons per b.h.p.-hour. This statement evoked lively criticism, but one firm of producer makers gives a figure of only 600 gallons per hour for a 1500b.h.p. producer; another firm works on the assumption that six gallons of water per b.h.p.-hour are sufficient for all producer purposes. In addition to the water for the producer, water is required for the engine jackets. Some makers do not water-jacket the pistons of lower-power engines; but assuming these to be water-cooled, let us allow that 12 to 15 gallons per b.h.p.-hour is sufficient for all engine and producer purposes. For condensing purposes in this country, an average figure for circulating or injection water is 35 times the weight of steam condensed, in the case of the steam plant, therefore, 52.5 gallons are required as against a maximum of 15 gallons for the gas plant, and taking the irrecoverable water as well, we get a ratio of 54 to 15. In the case of steam turbines requiring a high degree of vacuum, the proportion will generally be much higher. This is important, and if the water supply be unfit for use in boilers without purification, it is quite clear that the gas plant scores still higher. With regard to the works cost items of wages, stores, repairs, and maintenance, the gas plant and engine do not involve any more skill or more attendants than steam plant, especially when all auxiliaries are taken into account. The producer requires no more skill than a boiler, and an unskilled man or ordinary attendant can as easily run a gas engine as a steam one. As a matter of fact, there is nothing to choose between the items of wages and running stores for the two plants, and while it is certain that in the earlier days of large gas engines, whatever the type, the repairs and maintenance account was exceptionally high, it is equally certain that this item is now but little, if any, higher than in the case of the steam engine. As regards the producers, this item is undoubtedly much less than for boilers, so that in the long run the balance is even between the two. One word about lubrication, which is popularly supposed to be excessive in gas engines—provided the lubricating arrangements are well carried out and a minimum amount of oil is applied at proper points, there is no cause to fear a heavier consumption than with steam engines.

The suction producer is certainly by far the cheapest to instal, consisting, as it usually does, of three elements only—the producer proper generally containing the boiler or vaporiser into which a small quantity of water is fed, and from which it is taken as steam to the fire-grate; the coke scrubber, used for cooling the gas and taking out the heavier dirt and tarry matter; and the sawdust cleaner for effecting final purification: this description is common to all suction producers except that the elements may be arranged somewhat differently.

The pressure producer for bituminous coal is a more expensive generator to instal on account of the large proportion of volatile hydrocarbon which is distilled from the coal as tar, and must be removed if the engine is to run satisfactorily. The presence of tar in the gas is not only prejudicial because it clogs up the cleaning plant, as well as the internal valve mechanism and other parts, but also because of the trouble which arises if particles of tar get lodged inside the cylinder. They incline to remain incandescent and ignite the incoming mixture at the wrong time, and also form an exceedingly hard carbonised scale, which tends to wear both cylinder and piston. Sulphur in the gas is most detrimental; it does not occur to any extent, as a rule, but if it does, and water be present, there is always risk of corrosion. Some cokes and some Continental anthracites have this objectionable quality, but, generally speaking, it does no often occur in British coal.

As to regularity of turning moment of gas engines, the difficulties of this have generally been overcome; they certainly did exist, sometimes in a most marked degree, with the old single-acting type of engine; but there are double-acting two cycle gas engines coupled direct to and driving three-phase fifty-cycle alternators in parallel with perfect synchronism, which the author has seen, and he has actual knowledge of other similar gas engine sets running in parallel with each other and with steam-driven alternators.

The author concludes with a summary of actual results substantiating the foregoing remarks concerning reliability and economy. These include:—

A plant consisting of two engines capable together of giving 500 electrical h.p. continuously at the switchboard. The calorific value of the bituminous coal used during three recent tests, each of twelve hours duration, averaged 12,250b.t.u. per pound, and the gas varied between 140 and 152b.t.u. by analysis. The fuel consumption in the producer averaged 1.3lb. per kw.-hour, a most remarkable result. The engines have run for many weeks continuously, with rare stoppages, from 7.30 a.m. on Monday, till noon on Saturday, and operate in parallel with steam-driven sets situated in another engine room.

The engineer states that the cost per kw. hour works out distinctly cheaper than if produced on the high-speed steam plant, in spite of the fact that the capital charges per unit on the gas plant are distinctly higher than they will be when it is brought up to its full capacity of 1000e.h.p.

From a large ironworks in the Midlands, the manager writes :—" It may interest you to know that formerly (with steam) we used about 2000 tons of coal, costing us about £1020 per annum, whereas now (with gas engines and bituminous coal pressure plant) we are using about 326 tons, costing about £195." This means a reduction to one-fifth of the original fuel bill; but it is only fair to point out that the old steam engine plant was admittedly uneconomical.

In another case, where a 500b.h.p. gas plant replaced a steam plant of equal capacity, the saving is one-third of a penny per b.h.p.-hour, which, at ten hours a day and 300 days a year, is equivalent to about £2000, notwithstanding the fact that a greater amount is allowed for depreciation on the gas engines than was allowed for the steam.

Several tests were carried out on a gas plant aggregating about 1000h.p. The engines have been driving dynamos for some time now, and the results showed that the fuel (Yorkshire) gasified per kw.-hour was 1.43lb. on full load and about 1.47 on three-quarter load.

The following two cases are from Mr. Dowson's interesting work on "Producer Gas." At the Birmingham Small Arms Factory, with a 250b.h.p. plant, the total fuel consumed was 1.9lb. per kw.-hour, and the total water used in the gas plant (not the engine) was one gallon per kw.-hour. At the Hoffmann Manufacturing Company's Works, at Chelmsford, a test run of 123 hours was made without a stop, and readings were taken every half-hour. The consumption of anthracite peas in the suction producer worked out at 1.23lb. per. kw.-hour.

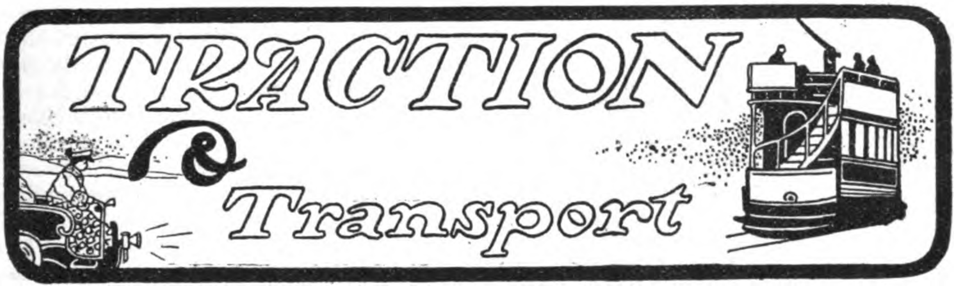
At the Guernsey Electricity Supply Company's station, visited about two years ago, and which at that time was run at very light load, the figures for total working cost come out to practically 0.5d. per unit.

In a works where a 270b.h.p. gas engine was installed at the beginning of last year, the gross coal consumption, taken over ten days on irregular load, and including stand-by losses, worked out at about 0.9lb. per b.h.p. hour on an average of about three-quarter load. This engine is driving a mill, but if it were driving a dynamo having 93 per cent. efficiency, you will see that this works out at under 1.3lb. per kw.-hour. In this case the gas plant consumes from 1-6th to 1-7th of the coal formerly used in the steam plant; but the latter was not of modern or economical design.

In another and larger plant, the total generating costs work out, on three months' ordinary running, at 0.135d. per unit, probably the lowest actual working costs on record. The load is certainly steady and continuous; but to even double or treble this figure, to contrast the running of this plant with one having the load-factor of an average Corporation station, one gets a generating cost much below that of any steam station having units within the limits of size which we have been discussing.

Individual tests on gas plant for short periods are perhaps unconvincing, especially, of course, with regard to reliability. They are, however, directly comparable with similar tests on steam plant as far as coal consumption goes. The author has certified reports of the following : 1.43lb. of coke per kw.-hour; 1.23lb. anthracite per kw.-hour, with a further test on the same plant of 1.29lb. per kw.-hour, and 7¼ gallons of total water consumed per b.h.p.-hour ; another of 1.03lb. coke per b.h.p.-hour, and so on. On a 350b.h.p. gas plant driving cement works in Germany, 1¼lb. of very low grade lignite briquettes were used on a long test run per b.h.p.-hour.

Finally, there are the results of operating the Schwerin Electricity Works, where two 350b.h.p. gas engines are used for driving d.c. machines for lighting. Taken *over the whole first year of operation* the gross coal consumption, including all losses and stand-by charges, amounted to 2.2lb. per kw.-hour, while during the first six months of 1906 the average gross coal consumption per unit generated, not on specific tests, but in actually weekly running, was 1.9lb. per kw.-hour, and that on a very poor load factor.



A classified list of Traction and Transport articles will be found in the World's Electrical Literature section.

Rectifier for Electric Locomotives.

THE system of electric traction proposed by MM. Auvert and Ferrand, engineers of the Paris-Lyons-Mediterranean Railway, is one in which the current supplied is alternating, while direct-current motors are used for driving the locomotive. The locomotive is equipped with a special form of regulating rectifier which receives alternating current at constant voltage and delivers direct current at a voltage which can be varied at will, according to the demands of the driving motors.

The novel feature of the system resides in the regulating rectifier. Fig. 1 gives a representation of the circuits of the rectifier reduced to a two-pole model. The commutator is made up of two large conducting segments, which are connected direct to the alternating current slip-rings and between which are joined the two parts of the rectifier winding, in addition to numerous small conducting segments tapped to the rectifier windings at regular intervals. The two pairs of the rectifier winding surround a continuous magnetic circle shown in the illustrations as being similar to a Gramme ring, but the parts are so arranged that the current which passes from one large commutator segment to the other flows in such a way as to produce two magnetomotive forces in series in the magnetic ring. Thus, when an alternating e.m.f. is impressed between the two slip rings, the windings and the magnetic circuit act in every respect like the primary winding and core of an alternating-current transformer, or, as the equipment is used, as the single winding of an auto-transformer. The small commutator segments serve as the contact devices for taps from the auto-transformer. Two brushes are arranged to bear continuously upon the commutator, which, as noted above, is formed of the two terminal pieces and the intermediate contacts of the auto-transformer. The addition of means for driving the commutator and auto-transformer in synchronism with the alternations of the supply current completes the essential details of the rectifier.

It will be apparent from a study of Fig. 1 that with the two brushes placed diametrically opposite each other the instantaneous value of the e.m.f. between them will depend upon their mechanical position with reference to the terminal pieces of the auto-transformer, and upon the value of the e.m.f.

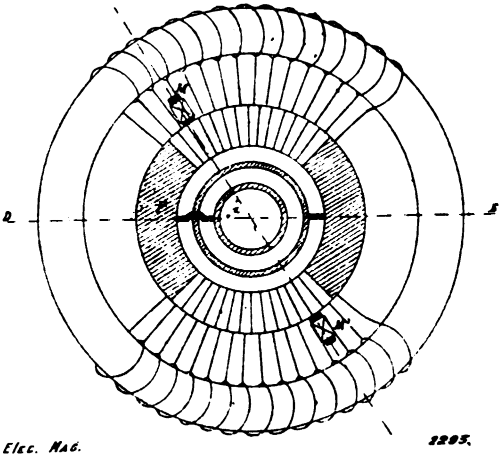


Fig. 1. Diagram of Rectifier.

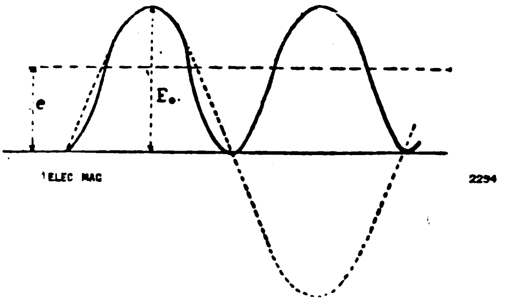


Fig. 2. Relation of Impressed and Delivered E.M.F.'s.

impressed between them. If when the alternating e.m.f. has its maximum value the synchronously rotating element is in the position to cause each brush to be in the centre of a terminal piece, then the time-value of the e.m.f. between the brushes will be similar to the heavy curve of Fig. 2, provided the alternating e.m.f. has a time-value similar to the dotted curve. Thus the delivered e.m.f. is unidirectional, but fluctuates in value from a certain maximum to zero twice during each cycle of the alternating e.m.f. A little further consideration will show that the delivered e.m.f. can be given any desired value from the maximum to zero, by decreasing the arc of separation between the brushes from 180deg. to zero. In practical operation the voltage impressed upon the direct-current motors is varied throughout the required range by shifting the brushes on the rectifier. On account of this characteristic of the machine, it has been given the name "regulating rectifier."

As intended for railway use the machine differs in minor details from the simple bipolar model described above. Fig. 3, which is a diagram of the electric circuits of a rectifier equipment designed for railway work, shows that the high potential alternating current is fed in parallel to two step-down transformers whose secondaries are connected to the slip rings of two distinct rectifiers, the delivery circuits of which are joined in series. The series connection of the delivery sides of the rectifiers is desirable on account of the fact that each machine operates better at a lower than at a higher e.m.f., and the e.m.f. necessary for traction is greater than the value that can conveniently be obtained from one rectifier. It will be seen from Fig. 3 that each rectifier is provided with two commutators and two distinct sets of auto-transformer windings. This construction has been adopted for mechanical symmetry, and in order that the core material may be economically utilized. The two auto-transformer windings can be

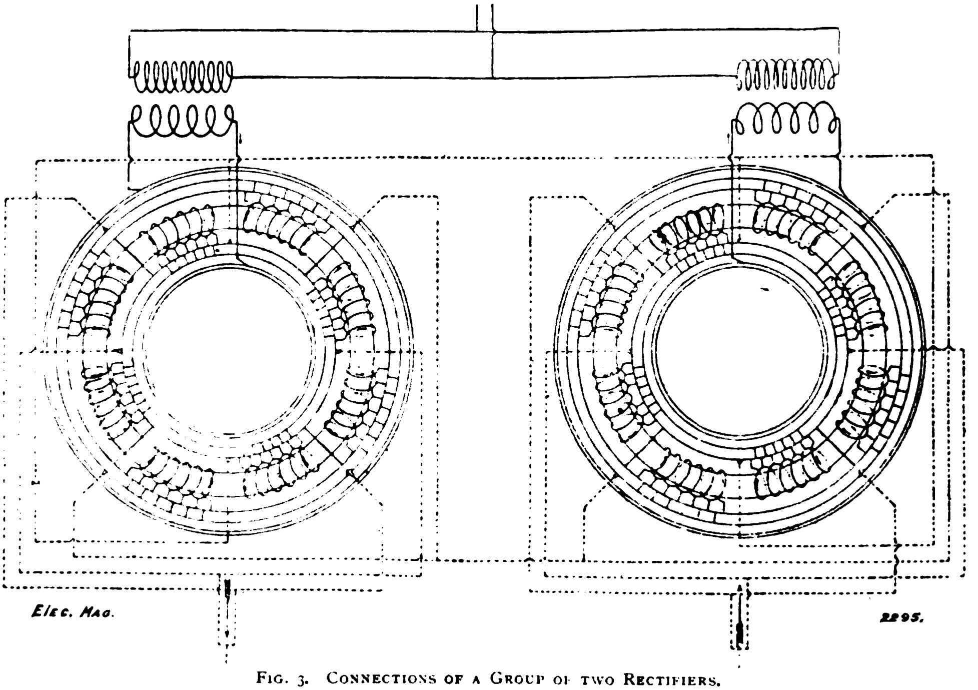


Fig. 3. Connections of a Group of two Rectifiers.

arranged for series connection, although the arrangement is somewhat simpler when they are connected in parallel, as shown in Fig. 3.

A plan view of two regulating rectifiers direct geared to a synchronous motor is given in Fig. 4, while a longitudinal sectional elevation of one of the rectifiers is shown in Fig. 5. It will be noted that the revolving element of each rectifier resembles somewhat the armature of a rotary converter except that it is provided with two commutators. A striking difference in mechanical detail is found, however, in the fact that there is no part to correspond to the field structure of the rotary, and the machines are essentially different electrically in that there is no transformation of electrical into mechanical power and the rectifier proper is incapable of maintaining itself in motion. The synchronous motor serves merely to revolve the rectifier at synchronous speed,

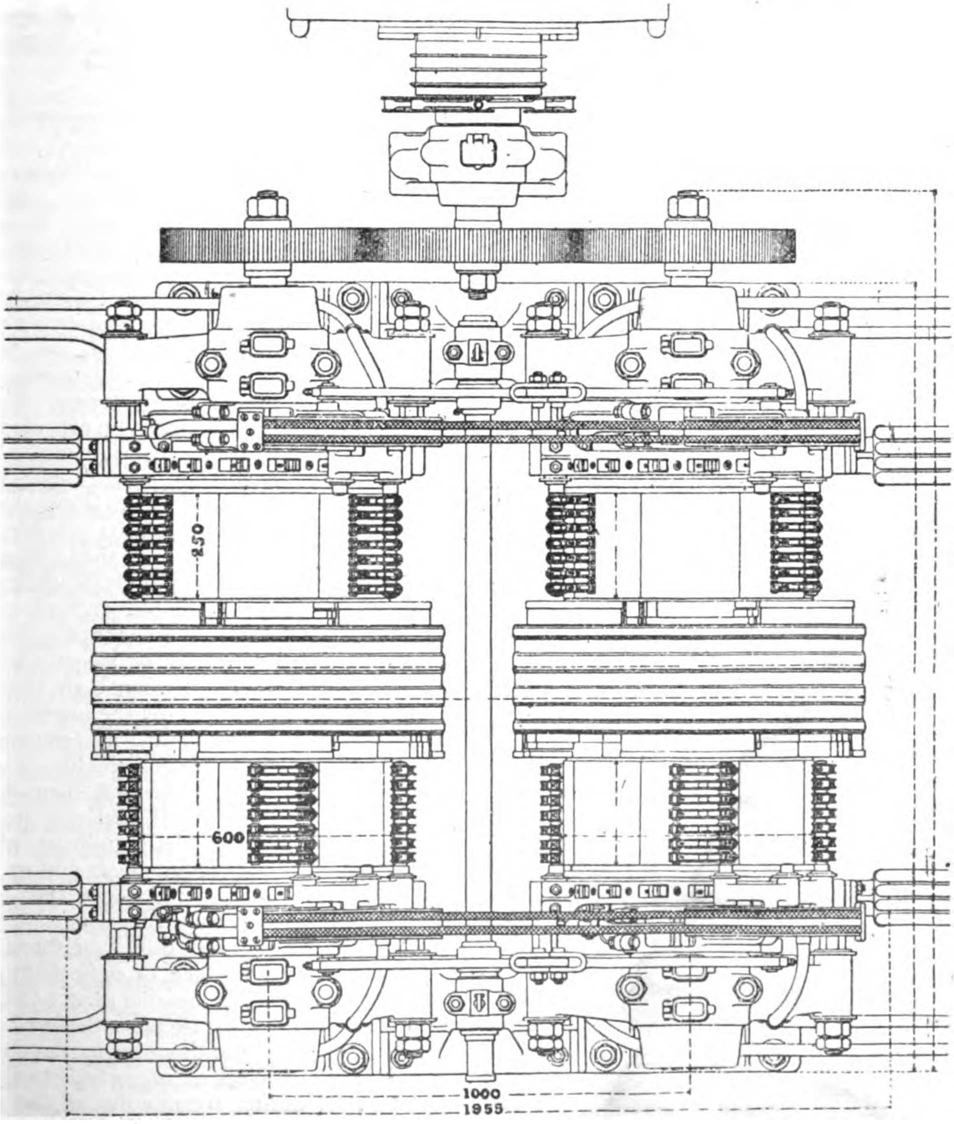
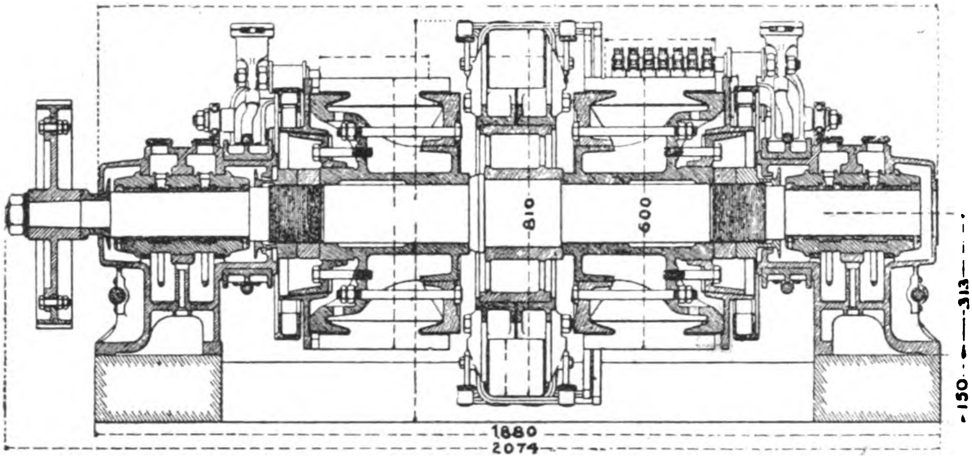


Fig. 4. Plan of Rectifier Group.



Elec. Mag. 2297.

Fig. 5. Sectional Elevation of Rectifier.

and it is relatively small in size. The rectifiers shown in Fig. 4 have a combined direct-current capacity of 400kw. at 235 volts, the alternating e.m.f. impressed upon each rectifier being 155 volts, the efficiency at full load being 91 per cent. By shifting the brushes the e.m.f. can be varied from 20 to 280 volts with a constant supply pressure of 165 volts. It is stated that the commutation is excellent at 1500amp., and that loads of 2100amp. have been carried without difficulty. The locomotive to utilize this rectifier is now being built for the Paris-Lyons-Mediterranean Railway by the Alioth Electric Company, of Paris.—*Street Rly. Journ.*

Fuel Consumption of Steam and Electric Railways.

Data contained in the anhual reports of a number of the larger steam railways, says the *Electric Railway Review*, indicate that the annual coal consumption is on the average about 2500 tons for each steam locomotive, and the cost of fuel is about 15 per cent. of the total operating expenses of the road.

From the United States census report on "Street and Electric Railways," covering 799 operating companies, the cost of fuel for power for electric railways appears to be about £3,000,000, which is a little over 10.5 per cent. of the total operating expenses. This figure is higher than would be obtained were only companies having the more modern generating plants included; in the census report is given a table based on the accounts of seventeen selected companies in large cities which shows the average cost of fuel to be 7.2 per cent. of the total operating expenses. In view of recent improvements in power plant design strictly modern power houses might be expected to show an even smaller cost for fuel. In attempts which have been made to compare the fuel consumption of steam locomotives, with a view to getting data on the savings railways might expect from the adoption of electricity for a motive power, the difficulty has been to find a suitable unit of comparison that would represent exact conditions. The fuel economy of locomotives is at a great disadvantage when their average performance is measured by the useful work performed and compared with stationary engines and boilers. When the locomotive is at work and well under way hauling a train, the consumption of coal per horse-power-hour is low, but it is found that while the locomotives are under steam and in the hands of the transportation department they are not making mileage more than 50 per cent. of the time, and based on the total time there is an average of only about five miles per hour for freight service where schedules of fifteen to twenty miles per hour are the rule. All the time the locomotive is standing at terminals or on sidings awaiting orders, it is during six months of the year exposed to the cold winds, and the losses of heat through radiation are considerable.

Tractive Effort of the Single-Phase Commutator Motor.

B. G. BERGMAN.

ONE of the objections—by many considered as serious—to the use of the single-phase commutator motor for traction, and especially for heavy traction with locomotives, is the effect of the pulsating torque, which is characteristic of these motors.

The torque is proportional to the product of field strength and armature current. Consequently, if a sine wave variation be assumed of the same frequency and phase for each of these factors, the torque will vary as the square of a sine wave. In other words, the torque, being always uni-directed, will pulsate between a zero and a maximum value. Such a pulsating torque is equivalent to a uniform torque—as exerted by direct-current motors—equal to the average of the instantaneous values during a full pulsation. It would seem, therefore, that the result would be that the same locomotive could start a heavier train when equipped with direct-current motors than it could with an alternating-current motor equipment. For a given service this would mean an increased "dead" weight with resulting greater losses, if using the alternating system. Hence the gain in other respects by its use would be more or less counteracted.

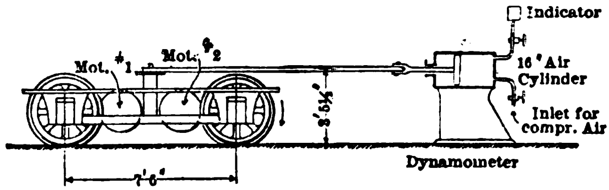


FIG. 1. APPARATUS FOR SLIPPING TEST.

It is well known that the friction between a body and its support is greatest when the body is at rest; as soon as it is forced to slip the friction decreases. From several tests it has been shown that this decrease takes place at a smaller rate with increasing speed of slipping. Hence the maximum tractive effort or the maximum force between wheel and rail is obtained at the moment before the wheel starts to slip. This tractive effort is the limit for the useful pull with a uniform torque equipment. With an alternating equipment, on the other hand, supposing the pulsations transmitted to the rim of the wheel, the maximum "useful" or average pull will evidently be lower, as necessarily the slipping point will be reached first by those values of the pulsations which are above this average.

Looking at the matter from a purely theoretical standpoint, and not considering the possible disturbing elements, it is evident that, when during the pulsation the slipping point at first is reached, the wheel begins to slip, and will be accelerated until the acting force decreases and equals the frictional resistance. Then the wheel will be retarded, and when the energy stored during the time of acceleration has been fully dispersed, the wheel, of course, stops. Thus there will be a periodical slipping of the wheel before the continuous slipping—as resulting from a uniform torque—takes place. This evidently occurs when the periodical slips are no longer interrupted by any stops. Then the maximum useful tractive effort of the alternating equipment is reached.

Considering that the time for acceleration during the periodical slip becomes shorter with increasing frequency, it is clear that also the speed of slipping will decrease. Now, referring to the variation of the coefficient of friction with the velocity, it seems probable that the maximum useful tractive effort will increase with the frequency and become equal to the static adhesion at infinitely high periodicity. If the dynamic friction were equal to the static friction, the maximum useful or average tractive effort would evidently be the same for a pulsating as for a uniform torque in spite of the periodical slips.

In this connection may be mentioned the influence of the "tilting" when produced by a pulsating torque. As is well known, the "tilting" acts in a way to lighten the front end of the vehicle. This is, of course, especially noticeable at the start, when it shows itself by the front wheels being slipped before the rear ones. If the acting torque is pulsating, the "tilting" is greatest when the force driving the wheels has its maximum. Hence the front wheels should slip earlier and the hind wheels later if the "tilting" is pulsating than if it is uniform but of an equivalent value. Due, however, to the general great mass of the vehicle and the considerable amount of spring used for suspension, the "tilting" pulsations will be practically eliminated, and the maximum

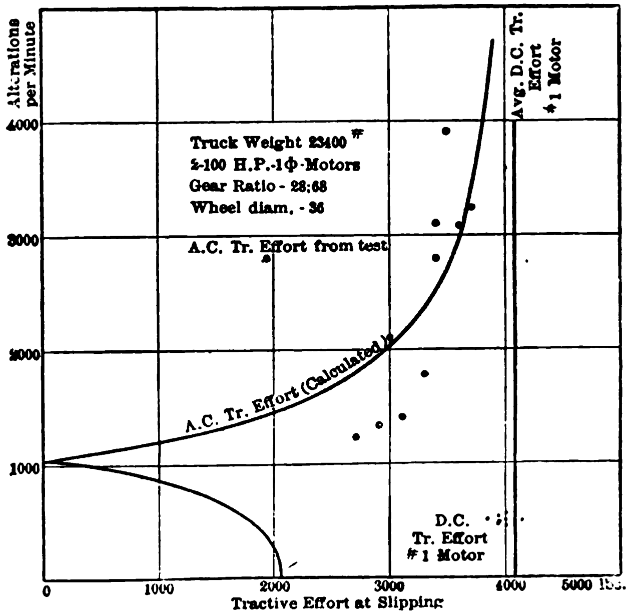


Fig. 2. Test and Calculated Results.

useful pull will be influenced mainly by the fluctuations of the driving force itself.

Considering the matter solely from the above points of view, it is obvious that the maximum useful pull must be lower with an alternating than with a direct current equipment. There is, however, actually a phenomenon taking place, which certainly is the more important as it tends to eliminate the very cause of the lower maximum useful alternating pull. This phenomenon is due to the elasticity in the different parts transmitting the pulsating forces, and is clearly illustrated, for example, by an alternating-current ammeter of the dynamometer principle. Although the torque is pulsating, the moving coil with the needle is perfectly still. The spring counteracting the deviation of the needle is consequently exerting a constant torque.

The principle is clear. The moment of inertia of the body must be great, and the greater the better, as necessarily then the acceleration, and consequently the motion, will be less during the different time intervals of the pulsation. Evidently an increase of the frequency will have the same effect. It is further obvious that the larger the deflection of the spring for a slight variation of the acting force, or, in other words, the smaller variation of the torque of the spring for a given deflection corresponding to a certain motion of the body, the more the torque transmitted by the spring will approach a uniform value.

As this phenomenon can be mathematically expressed, there is a convenient way open to get an idea of the influence of the elasticity in the present case by making a calculation based on actual data; the results of an actual test are given below.

Fig. 1 shows the arrangements for the test and Fig. 2 indicates the results. A standard truck, equipped with two 100h.p. single-phase motors, was placed on rough rails. As a dynamometer there was used a 16in. air cylinder, and the pressure was registered by an indicator. Through the motors was sent alternately direct and alternating current. The current was slowly increased until the wheels slipped, and it may be noted that the slipping point was very sharply marked by the instruments. One motor was used at a time, and on the curve sheet are plotted points indicating the results for motor No. 1. The only difference in the results for the two motors was that due to the unequal weight on the wheels as produced by "tilting."

The test evidently shows an increase in useful tractive effort with increasing frequency in accordance with the above conclusions. As far as it is possible to judge from a test of this kind, with so many varying and uncertain elements entering it, the tractive effort for slipping the wheels at the commercial frequency of 25 cycles per second is about 15 per cent. smaller for alternating current than for direct current, assuming, of course, that suspension, gear arrangement, &c., are the same as for the truck used in this test.

The drawn curve shows the calculated value of the alternating-current tractive effort as found by considering the moment of inertia of the moving parts referred to the axis of motion, the torque of the spring device per unit of angular deflection, and the slipping point, which corresponds to a tractive effort of 4100lb., as obtained from the direct-current tests. This curve passes almost through the test points at about 3000 alternations, thus giving the same tractive efforts as the test. The maximum angular deflection of the spring device is only .225deg. It is interesting to note the point where the curve reaches the frequency axis. This point corresponds to the case when the "impressed" frequency equals the "natural," or, in other words, when resonance occurs.

The curve is, however, "pessimistic," as will be seen from the following: In its derivation the acceleration of the wheels when slipping was not taken into account, due to the complications it would involve. The result would, however, be a higher tractive effort for alternating current. When the wheels begin to slip continuously the maximum value during the pulsation must be higher than is assumed—that is, than the value of the absolute static friction. As the tractive effort with alternating is less than with direct current, the "tilting" must also be less; consequently the weight upon the driven wheels must be greater, hence the slipping point higher than is assumed. Further, the damping effect has not been taken into account. Taking these things into consideration, the curve is especially "pessimistic" at low frequencies, as evidently with increasing frequency the above-mentioned effects have less influence.

It is further obvious that the maximum average tractive effort can never be lower than corresponds to the lowest value of the "dynamic" coefficient of friction. Hence actually the lowest part of the curve (above "resonance") would be bent down instead of as shown on the curve sheet. If the dynamic coefficient of friction were constant—that is, independent of the speed of slipping—the curve should have a sharp bend at the corresponding point, but, due to the decrease of the "dynamic" friction with increase of speed of slipping—as discussed above—the curve would probably bend down gradually, giving a minimum of tractive effort at "resonance," as shown on Fig. 2.

Before making the final conclusions some words may be said about the influence of the oscillations of the motor itself when it is geared to the wheel axle. The motor will tend to move in the same direction in which the reactive force from the gear acts upon the teeth of the pinion. Consequently if an oscillation of the motor frame is possible the armature must revolve correspondingly, and the more, the larger the amplitude of the oscillation. Considering the torque taken up by the moment of inertia of the armature, it is evident that the pulsations of the driving force upon the wheels can be eliminated by the oscillations of the motor frame and without elasticity between the armature and the wheel. A theoretical analysis also shows that the pulsations of the tractive effort can be entirely eliminated by suitably arranging the suspensions, but that exceedingly stiff springs are necessary.

As conclusion it can be said that a 25-cycle alternating-current equipment with geared motors, connected to the wheels in the standard way, seems to have about 15 per cent. less maximum tractive effort than a direct-current equipment, and that evidently considerably worse results would be obtained with gearless motors the armatures of which were rigidly connected to the wheel axles; that with both geared and gearless motors, the alternating-current equipment can exert as high a tractive effort as a direct-current equipment by introducing sufficient elasticity somewhere between the armature of the motor and the rim of the wheel; that a rather slight flexibility is sufficient, and that, therefore, perfectly practicable and reliable devices can be designed for such a purpose.

Finally, it may be said that the greater cost for such a device and for its maintenance will probably be many times outweighed by the savings obtained by its use, as resulting from increased tractive effort and from less troubles to motors, pinions, &c., the cushioning effort of the device practically eliminating sudden shocks.—*Elec. World.*

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Operating Costs of Electric Mining Locomotives.

An example is taken by a writer in *The Engineering and Mining Journal*, in which fourteen mules are replaced by a single electric locomotive. The cost of the mules and harness is $2870. The working expenses, including care of the mules, drivers, interest and depreciation, are $6577; so that the cost of hauling the 367,500 tons yearly load delivered by these animals is 1.8 cents per ton. The electric locomotive and generating apparatus would cost $11,200. The working expenses, including interest and depreciation, are $4617.50. This locomotive would haul the same amount of coal as the mules, and the cost would be only 1.27 cents per ton. No allowance is made here for the cost of the stable for the mules nor for losses by accident.

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Central Station Supply Economics.

Their Study, and what it promises in the way of Cheaper Supply.[*]

A. M. TAYLOR.

DEFINITIONS.—Plant Load Factor.—The ratio of the average load on the generators, taken over the year, to their aggregate rated power (not overloaded).

Station Load Factor.—The ratio of the average load on the station feeders, taken over the year, to the maximum observed load on the station.

Consumers' Load Factor.—The ratio of the average load (taken in b.h.p.-hours where motors are concerned) given out, or absorbed, by consumers' apparatus, to the maximum possible capable of being absorbed or given out.

Internal Diversity Factor.—When applied to a motor load, this represents, at any instant, the number of times which the sum of all the maximum loads on consumers' premises exceeds that observed at the central station.

Unrealised Diversity Factor.—This is the amount by which the observed diversity factor falls short of what it should be in order to satisfy the equation: Consumers' load factor × average diversity factor = station load factor.

Running Charges and Fixed Charges.

Every item of annual expense may be divided into three parts:

A part termed the running charge, proportional in amount to the number of units generated; a part independent of the number of units, but dependent on the maximum demand of the station; a part dependent on the number of consumers. Without great error, the last two items may be classed together as standing charges. The author proposes to consider these charges both in their relation to a lighting load, to an ordinary "interest-paying" motor load, to a traction load, and to a restricted hours load.

1. *Coal.*—In order to fix ideas and facilitate the investigation that follows, the author has represented in Fig. 1 the coal performances of a complete station, whose most economical (engine) load is 3000kw. This station might consist of two 500kw. sets, two 1000kw. sets, and a spare 1000kw. set.

The curve (A B) represents the engine performance alone. It is really a steam performance at the engine stop-valve; but may be expressed on the diagram as a coal performance. Boiler standby losses, steam range and auxiliary plant losses, looking at the station as a whole, bring the curve up to (A′ B′). The curve (C D) similarly represents the steam consumption, for the engine only, expressed as lbs. of coal per unit generated; and the curve (C′ D′) represents the lbs. of coal per unit generated, including boiler standby, steam range and auxiliary plant losses, for the whole station.

The importance of the plant load factor upon the determination of the standing charges for coal is obvious; this item being only 3lb. (7–4) of coal per unit, for a 25 per cent. plant load factor, whereas it is 9lb. (13–4) for a 12 per cent. load factor.

Knowing the average engine consumption on test at different loads, the plant load factor, and the total consumption per unit

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[*] Abstract of Paper read before the Institution of Electrical Engineers, Birmingham Local Section, February 13, 1907.

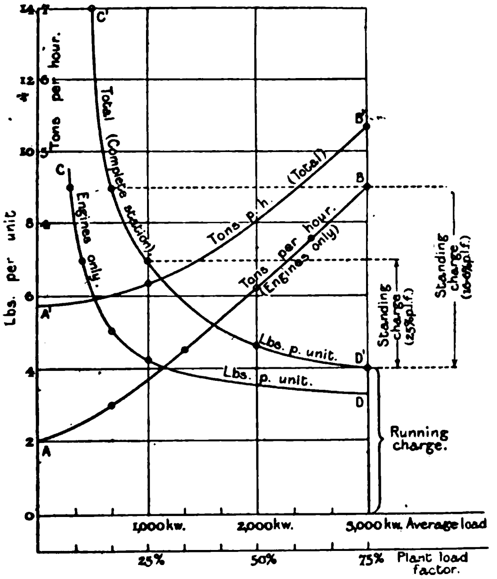

FIG. 1. COAL DIAGRAM FOR STATION.

Maximum Boiler Evaporation taken at 7lb. per lb. of coal. Most Economical Load = ¾ Rated Load = 3000kw.

averaged over the year, as well as the boiler coal consumption under test when feeding the engine and the auxiliaries, we can construct the four curves of Fig. 1 and learn the relation of "running" and "standing" charges for coal. Obviously, the steam consumption accounted for by the engines, on the plant load factors frequently obtaining (such as 40 to 50 per cent.), leave the unaccounted coal consumption as that chargeable to the stand-by losses of boilers and auxiliary plant.

Let us now investigate somewhat more carefully into the 4lb. of coal taken as the running charge in the above figure.

Assume the whole station to be working at its maximum economical load for the complete twenty-four hours, so that it should be possible to realise the guarantees of the makers for the evaporation of the boilers and the steam consumption of the engines, and to eliminate all stand-by losses in boilers, pipework, auxiliaries, &c.

It has not, for some years past, been difficult to get a 300-500kw. set whose steam consumption (condensing) is less than 25lb. per kw. on full load, employing superheated steam. Add to this, say, 15 per cent. (3.75lb.) for steam consumption for auxiliaries (also working under best conditions) including condensing plant, loss in steam ranges, traps, &c., and we have a total of 29lb. of steam per electrical unit for an easily-attained figure for the most economical load, maintained constant all through the twenty-four hours.

It is also comparatively easy to get a boiler which, when worked under similar conditions, will evaporate 7lb. of water from feed at 210deg. F. to steam at 180lb., with 100deg. F. of superheat, for every lb. of slack (11,000b.t u.) costing, say, 7s. 6d. per ton (*i.e.*, 0.04d. per lb.). Hence, as a round figure, 4lb. of slack will evaporate 29lb. of water required, at a cost of 0.16d. per unit generated.

By substituting the corresponding values for the thermal value of the fuel at any particular place, and the cost of the fuel, the "running charge" for coal can at once be found for that town.

Owing to stand-by losses of all kinds, the actual coal consumption in stations of about 1000 to 2000kw. capacity will be from 8 to 12lb. per unit or even more; but the above figure of 4lb. per unit represents the whole of the additional coal consumption which would be incurred were we able to eliminate starting up and stand-by losses by throwing upon the station a load (such as a restricted hour load) which merely filled up the capacity of boilers and engines that were not running at their most economical load, though obliged to be kept under steam to deal with the evening "peak" or occasional fogs in the daytime.

In a station where a combined lighting and traction supply is given, the number of boilers in commission all through the year would, in most cases, supply such a (restricted-hour) load, if of moderate dimensions, without further boilers being required to be started up; and in this case the above figure of 0.16d. per unit would still hold for the charge debitable to that load.

In a non-traction station, however, it would be necessary for perhaps three months out of the twelve to keep in commission an extra boiler, to deal with the above class of load, unless very moderate in dimensions, and in such a case the above figure of 0.16d. per unit might be increased to, say, 0.20d. per unit (generated).

We may summarise the above investigation by stating that:—The coal bill for a lighting station of about the capacity stated will be made up of two items, viz., a "running charge" of 0.16d. per unit (generated) plus a "standing charge" of, say, 0.24d. per unit (generated). Also that an "interest-paying" power load is debitable on account of coal with a running charge of 0.16d. plus a stand-by charge of, say, 0.12d. per unit (generated); the stand-by charge being halved on account of the doubled load factor.

Again, a traction load is debitable on account of coal with a running charge of 0.16d. plus a stand-by charge of 0.10d. per unit generated, the load factor in this case being taken at $2\frac{1}{2}$ times that of the lighting.

Again, a restricted hour's load, provided it is not unduly developed, is debitable, on account of coal, with a running charge of 0.16d. *only*, where there is a traction load in the station as well; but if there is no traction load, it is debitable with 0.16d. plus, say, 0.04d. (25 per cent. of 0.16d.) as running and stand-by charges respectively per unit generated.

Collecting and tabulating the above results, we have, for coal charges per unit (generated):—

Lighting.
Running charge = 0.16d.; stand-by charge = 0.24d.
Power.
Running charge = 0.16d.; stand-by charge = 0.12d.
Traction.
Running charge = 0.16d.; stand-by charge = 0.10d.
Average Combined Charge.
(For equal number of units, for all three classes of load.)
Running charge = 0.16d.; stand-by charge = 0.15d.
Combined charge = 0.31d.

Add 25 per cent. to all figures to bring them from per unit generated to per unit sold. It will be understood that the above figures refer to stations comparatively small in size, and that, with large stations employing units of 1000kw. and upwards, they would be very considerably bettered.

For example, with the largest and most up-to-date sets, a steam consumption of 18lb. per kw.-hour is attainable, and a boiler performance of $7\frac{1}{2}$lb. of water evaporated per lb. of slack (11,000b.t.u.), resulting in a coal consumption of not more than $2\frac{3}{4}$lb. of slack per kw.-hour, including a fair allowance for steam for auxiliaries and for losses in piping. The cost of $2\frac{3}{4}$lb. of slack at 0.04d. per lb. is 0.11d. per unit generated. The *total* cost, for coal, at Glasgow, for the traction load, including stand-by losses, does not exceed this. The object of the present paper, however, is to consider what may be done in the direction of cheapening power from the great majority of stations, and as we find them; and not to consider possibilities with ideal stations.

2. *Water and Petty Stores.*—It will be fairly safe to allow 0.02d. and 0.04d. per unit sold, for running and standing charges respectively for a lighting load; and 0.02d. and 0.02d. for a motor load, or a traction load; and 0.02d. alone for a restricted-hour load.

3. *Wages.*—It is, the author believes, a common practice to allocate *half* the cost of wages to running and half to standing charges, and this has perhaps some justification in the fact that it is exceedingly difficult to frame any hard and fast rule by which to determine the proportion between them. It would, however, appear to be distinctly unfair to allocate to either a traction, lighting, or power load such a large charge for the running cost as the above proposition would give.

Consider a station with a combined maximum demand for light and power of, say, 2000kw., of which 1000kw. are debitable to each class of load. In most stations such a condition postulates a power load development pretty far into the future, and hence the deductions that follow are financially safe.

Let the ordinate (C D) in Fig. 2 represent the total amount spent annually in wages on the combined scheme, and let (A B) be that which it is estimated would be required for wages on the lighting load alone; *i.e.*, assuming that the power load did not exist.

Join (C A) and produce through (A) till it

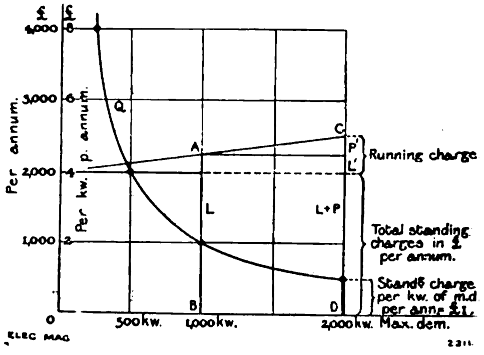

FIG. 2. WAGES DIAGRAM.

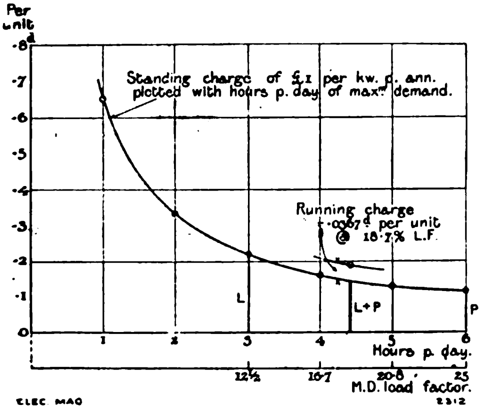

Fig. 3.

cuts the scale of ordinates at £2000 per annum. Draw a line horizontally through this point, as shown. Then, the total standing charges are represented by (L + P) and are equal to, say, £2000 per annum.

Hence the standing charge per kilowatt (of station maximum demand) is £1 per annum. We thus obtain the curve (Q), which gives us the standing charge per kilowatt for different combined maximum demands of the same station.

The running charges for light and power are (L′) and (P′) respectively.

If we assume a power load factor of 25 per cent. and a lighting load factor of 12½ per cent., the combined load factor will be 18¾ per cent.

In Fig. 3 the standing charge of £1 per kilowatt per annum is plotted with the charge per unit necessary to give this return, for different load factors, or hours of use per day, determined in the usual manner.

Superposed on this curve is plotted the running cost charge per unit, obtained by taking the sum of the running costs (P′ + L′), amounting to £500 or $\left(\frac{500}{2000} =\right)$ 5s. per kilowatt per annum. Now 1kw. per annum at 12½ per cent. L.F. = 1095 units, and at 25 per cent. L.F. = 2190 units, and at 18¾ per cent. L.F. = 1635 units.

Hence *average* cost per unit $= \frac{60.0\text{d.}}{1635 \text{ units}}$

= 0.0367d. per unit.

And cost per unit at 12½ per cent.

$$\text{L.F.} = \frac{60.0\text{d.}}{1095 \text{ units}} = 0.548\text{d. per unit.}$$

And cost per unit at 25 per cent.

$$\text{L.F.} = \frac{60.0\text{d.}}{2190 \text{ units}} = 0.274\text{d. per unit.}$$

We may, without material error, call the average figure a constant charge, viz., 0.0367d. per unit; which again we may call roughly 0.04d. per unit.

Next, consider the case (Figs. 4 and 5) of a combined lighting, power, and traction load, each of a maximum demand of 1000kw.

Taking load factors of 12½, 25 and 30 per cent. respectively, and estimating the annual charges for wages, for a combined lighting and power scheme without traction (from the known expenses of *one with* traction), and for a lighting scheme alone, we find a combined standing charge per kilowatt of 13s. 4d. per annum (Fig. 4). From this, the curve shown in Fig. 5 is readily deduced, and to this again is added the average running cost (0.03d.) per unit, obtained by dividing the combined running charge of 5s. per kilowatt per annum by the number of units (1972) generated on a 22½ per cent. load factor, *i.e.*, the average of the load factors of the three classes of load. The curve so obtained gives for the values taken an average combined charge of approximately 0.11d. per unit generated; but as 0.15d. per unit sold is perhaps a more usual figure in the class of station we are considering, let us increase the values of Fig. 5 by 33 per cent., and we get, for price per unit sold:

Lighting.
Running expenses = 0.04d.; standing expenses = 0.20d.

Power.
Running expenses = 0.04d.; standing expenses = 0.10d.

Traction.
Running expenses = 0.04d.; standing expenses = 0.08d.

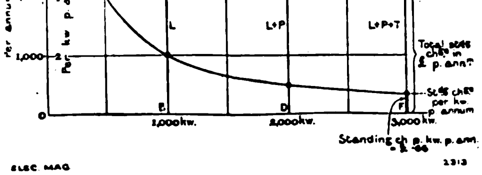

Fig. 4.

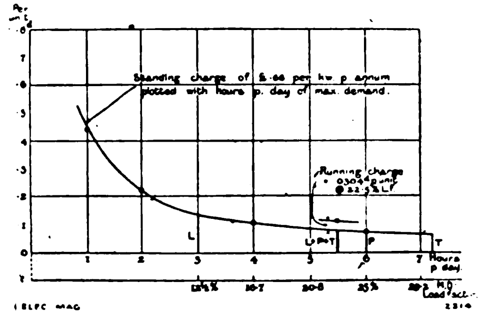

FIG. 5.

Average Combined Rate.

(For equal kilowatts):

Running expenses = 0.04d.; standing expenses = 0.109d.

Average Combined Rate.

(For equal numbers of units):

Running expenses = 0.04d.; standing expenses = 0.126d.

When the numbers of units are not equal, the method adopted must take account of this, as in the table below.

In the case of large systems having sub-stations, the wages at the sub-stations, without great error, may be lumped together with those incurred in connection with distribution, and the whole classed as standing charges. Or, if desired, the sub-station wages may be analysed in the manner already indicated for the generating station.

When the load is of the nature of a "restricted-hour" load, it will be evident that, so long as it is also restricted in *amount*, no charge on account of wages is debitable, the expenses of running the station being in no way enhanced on account of the new load taken on.

4. *Repairs and Maintenance.*—After the expenses of repairs to mains, e.h.t. feeders, services, meters, buildings (main and sub-station, including also offices), pipework, conveyors, cranes, stokers, economisers, condensers, pumps, switchboards, auxiliary plant, sub-station batteries, &c., are deducted, most of which are almost independent of the number of units turned out by the station, we have left for consideration a proportion of repairs which may perhaps represent one-third of the total capital cost. When one has further eliminated from this the expenses due to accidents—which may frequently wreck an engine or a generator in a few moments—or those due to break-downs through failure of insulation, or short circuits, in electrical plant or apparatus, it will be seen that we can only fairly debit to running charges that portion of repairs—probably about one-ninth of the whole—which is somewhat in proportion to the actual number of units turned out by the station, such as renewals of commutators, brushes, engine brasses, piston rings, boiler tubes, grate bars, &c.

The money values and the lives of these

	Load Factor.	Charge for Interest and Sinking Fund (averaged over all classes of Load).	Wages and Repairs.	Rates, Rent, Taxes, Management, Salaries, and Office.	Net Profit.	Average Total Charge (excluding Fuel).	Ratio Power Units. Light Units.	Ratio Power and Lighting Units. Traction Units.	Charge Debitable to Power Units* (excluding Coal).	Charge Debitable to Lighting Units (excluding Coal).	Charge Debitable to Traction Units (excluding Coal).
	Per cent.	d.	d.	d.	d.	d.			d.	d.	d.
Manchester (lighting & traction combined)...	21.1	0.78	0.36	0.20	0.33	1.67	2 : 3	2 : 3 : 6	1.44	2.88	1.15
Liverpool (lighting and traction combined) ..	22.8	0.74	0.19	0.25	0.39	1.57	2 : 8	2 : 8 : 20	1.38	2.75	1.10
Bradford (lighting and traction combined)...	24.6	0.73	0.34	0.21	0.02	1.30	2 : 2	2 : 2 : 7	1.22	2.46	0.98
Sunderland (lighting and traction combined)	*18.8*	*0.78*	*0.28*	*0.27*	*0.05*	*1.38*	*2 : 1⅓*	*2 : 1⅓ : 1⅔*	*1.15*	*2.30*	*0.92*
Glasgow (lighting and power)	*15.1*	*0.75*	*0.32*	*0.35*	*0.46*	*1.88*	*2 : 5*	—	*1.09*	*2.18*	—
Sheffield (lighting and power).............	12.1	2.16	0.31	0.22	0.06	2.75	2 : 5	—	1.59	3.20	—
Leeds (lighting and power)	*15.6*	*1.65*	*0.28*	*0.25*	*0.08*	*2.26*	*2 : 5*	—	*1.31*	*2.63*	—
Glasgow (trams)	30 (estimated Manchester)	1.32	0.16	—	—	—	—	—	—	—	—

* On basis of 25 per cent. load factor for power, 12 per cent. for lighting, and 30 per cent. for trams; and charges assumed *to vary strictly in inverse proportion of load factor.*

NOTE.—*Fuel costs and petty stores are not included in the figures given above.*

parts are capable of pretty easy estimation, for any particular station, and the author submits that such should be the basis on which the principal part of the running charge for repairs is based. After a margin of, say, 25 per cent. has been added to this charge, to cover incidentals in condensers and auxiliaries, the author submits that the whole of the other costs incurred in repairs and renewals should be lumped together and called the "standing charge."

Adopting the above suggested fraction of the total cost of repairs (viz., one-ninth) as being that due to running charges alone, and remembering that the standing charge has, in the case of a combined lighting, power, and traction load, to be divided among the three classes of load in the inverse proportion of their (station) load factors, let us roughly apportion these for a comparatively small station, having a maximum output of, say, 2000kw. (1000 lighting, 500 power, and 500 traction).

The combined charge for such a station is frequently of the order of 0.30d. per unit. sold. This would give:

Lighting.
Running charge = 0.033d.; standing charge = 0.422d.

Power.
Running charge = 0.033d.; standing charge = 0.211d.

Traction.
Running charge = 0.033d.; standing charge = 0.169d.

Average Combined Charge.
(For equal number of units):
Running charge = 0.033d.; standing charge = 0.267d.
Combined charge = 0.30d.

Before leaving the subject of repairs, an attempt to verify the above assumed figure of 0.033d. for the running charge is desirable.

The capital outlay for a maximum demand of 2000kw. would be for the station alone (*i.e.*, exclusive of feeders and mains) about £60 per kilowatt of maximum demand, or £120,000; and for boilers and running plant containing wearing parts, say £50,000.

The plant would turn out annually 2000kw. × 1972 units per kilowatt = 3,944,000 units (22½ per cent. load factor).

Taking the cost of the parts likely to be continuously under renewal, and in some measure in proportion to the number of units turned out of the station, such as grate bars, piston rings, boiler tubes, economiser tubes, condenser tubes, brasses, packings, commutators, brushes, to amount to, say, 5 per cent. of the value of the working plant in capital cost, *i.e.*, to £2500, and allowing an average life for these wearing parts (which, be it remembered, include the wearing parts of the spare units of generating plant) of, say, five years, we find that an allowance of 1 per cent. per annum of the capital cost of the boilers and running plant would be on the average a fair sum with which to debit the running cost.

Now, 1 per cent. per annum on £50,000 is £500 per annum, and hence we get the running cost per unit, viz.:

$$\frac{£500 \times 240}{3{,}500{,}000 \text{ units}} = 0.034\text{d. per unit,}$$

which sufficiently confirms the figure above assumed.

In the case of a restricted-hour load (subject to a restriction also as to its amount), the charge debitable to such a load is virtually only the "running charge" of the interest-paying motor load (viz., 0.033d.).

5. *Other Charges.*—To investigate in detail the other charges of the modern municipal station—interest, sinking fund, depreciation and renewals, management, office expenses, rent, rates, and taxes, &c.—would add too greatly to the length of this paper.

It may suffice to say that the great bulk of these charges, probably 95 per cent. of them, bear no direct relation to the number of units sold. An exception may, however, be made in the case of office charges, where perhaps 20 per cent. is chargeable to running expenses. On the other hand, this charge does not occur in connection with a traction load.

The method already indicated for determining the proportion of standing and running charges for wages can be applied, where desired, to any or all of the above.

(*To be concluded.*)

Modern Switchboard Devices.*

C. W. STONE.

THE oil switches of to-day are very necessary in high-tension systems for the distribution of energy, and to them is to be attributed the successful operation of such systems. The opening of an arc in the air on an alternating-current system is apt to result in dangerous rises in voltage, by causing surges in the system. Indications tend to show that an oil switch opens on the low point of the wave, or practically at zero current, and for this reason it has a tremendous advantage over any switch opening in the air.

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* Abstract of paper read before the New York Electrical Society.

A switch, which may be considered as an example of present oil switches for moderate capacities, has the operating mechanism and the contacts and the contact rods, etc., located on a top casting. The contact rods which pass through the casting are surrounded by porcelain insulators. These contacts are enclosed in an outside tank, which is filled with oil, barriers being placed between the different poles. Contact yokes are carried on the end of wooden rods, which are attached to the operating mechanism. The movement of the handle raises or lowers the yokes, bringing them when raised into connection with the contact blocks.

For very large loads a totally different design of switch is used. Each pole of this switch is made up of two cylindrical oil vessels, the bottom of which contains a contact. The oil vessels are mounted on large insulators placed in the base of a switch compartment. The two elements of each phase are separated from the other phases by means of brick or soapstone barriers. Passing through the top of the two oil vessels of each phase are two contact rods which are placed on a yoke. The yoke is fastened to the operating mechanism by means of a long wooden rod. The connections to and from the switch are made to studs passing through the insulators which support the oil vessels. The operation of this switch is exactly opposite to the one described above, as in this case the contact rods are pulled up from the contacts, while in the other type of switch the contact rods are dropped away from the contacts. The operating mechanism may be driven by compressed air or electricity. With the electrically-operated switch, the tripping is entirely independent of the motor, as the action of the switch is such that the motor carries the crank of the mechanism slightly past the centre, where it is held in position by a small toggle, which is opened by means of a small electro-magnet. Many improvements have been made in the small details of this type of switch since it has been in use. One of the latest and best improvements is in making the oil vessels of pressed steel. The original vessel was made of a seamless brass pipe. In the lower end of this pipe a bottom carrying the contact was soldered, and the top was threaded to receive the cap. The new type of vessel is made of steel, the top being put on in the same way as on the brass pipe.

Oil switches of the type just described are in successful use for e.m.f.s as high as 60,000 volts. In the 60,000-volt switches, the oil pots instead of being of metal are made of wooden staves somewhat like a barrel, held together by wrappings of cord. The pots are mounted on insulating standards.

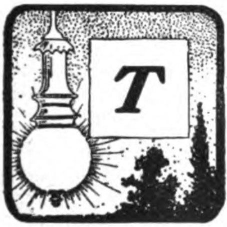
For alternating-current work a number of different types of relays are in use; the overload relay which has been generally used consisting of a simple solenoid and a set of contacts, so arranged that the movement of the plunger in the solenoid will properly operate certain contact mechanisms. The relays are made both for instantaneous operation and with time-limit arrangements. An excellent type of time-limit arrangement consists of a simple bellows placed above the contacts and fastened to the plunger. This bellows is provided with a small valve at the top, the opening of which can be adjusted so that the relay can be set for any desired time. With a relay of this type the time element is dependent upon the amount of current flowing through the solenoid, and is practically directly proportional to this current. Thus, if set for a certain time with a certain current, if the current is double, the relay will open in practically half the time, and in cases of short-circuit, it becomes practically instantaneous.

Another type of time-limit relay is the definite type which is made in two ways. One is the bellows type, which is very similar to the inverse time element type, the only difference being that the plunger is not rigidly connected to the bellows, but has a spring interposed in such a manner as to make the pressure on the bellows constant whenever the relay operates. The other form is a clock-work mechanism, which revolves a fan, the blades of which can be adjusted so as to require a pre-determined time of operation.

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Lighting and Heating.

*The Helion Filament Incandescent Lamp.**

H. C. PARKER and W. G. CLARK.



The name "Helion" has been selected because the spectrum of the light given by the new lamp is notably white, resembling the light of the sun. The features of the new filament are the method of manufacture, the high efficiency, and the peculiar physical characteristics. The filament is formed by depositing on a carbon filament, as a base, various materials, among which is silicon, which are introduced into the treating chamber as vapours. This process resembles the flashing process as employed in preparing ordinary carbon filaments. The constituents of the vapour are deposited on the surface of the carbon base and seem to penetrate deeply into it. The treatment is carried out in a special chamber, and after it is completed the filaments are removed and mounted in ordinary glass bulbs. This method is necessary because the current passing through the filaments during the treatment would fuse the platinum leading-in wires, and, also, the action of the vapours would affect the cement. The latest work in this direction has produced strong, elastic filaments which can be drawn out straight, even though they normally have a double loop, and which, upon release, resume exactly their first shape.

The results obtained by this treatment depend upon the conditions maintained. The longer the treatment, the greater is the percentage of silicon deposited on the carbon; and it would seem from tests which have been made that the smaller the percentage of carbon the higher the efficiency at which the lamp may be operated. Tests have been made in which the percentage of the coating varied from ten to seventy, which gave these results.

A noteworthy feature of this filament is that it operates at an efficiency of one watt per candle, but this rating is not fixed, as better efficiencies—in one case about three-quarters of a watt per candle—were obtained by longer treatment. What the ultimate rating will be cannot be said as yet. At present the inventors are satisfied to designate it as one watt per candle.

With this efficiency the question of useful life becomes important. No final figures can be given for this, because the greater part of the efforts of the inventors have been in the direction of determining the best method of treatment for producing reliable results. Lamps have, however, been made which have run for over 1200 hours. In one case the lamp ran for 1270 hours, starting at 37 watts and 37 candles. As the test progressed the candle-power increased to 40 and then again fell to 37, the consumption of power remaining constant. Lamps have been made which have run for 400, 600 and 800 hours, but no life tests have been made on more recent samples, as the time has not yet sufficed.

The physical characteristics of the new filament are remarkable. The efficiency of the lamp increases with an increase in temperature, and it is notable that the lamp begins to glow and gives a white light when

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[*] Abstract of Paper read before the Amer. Phys. Soc., N.Y., Dec. 29th, 1906.

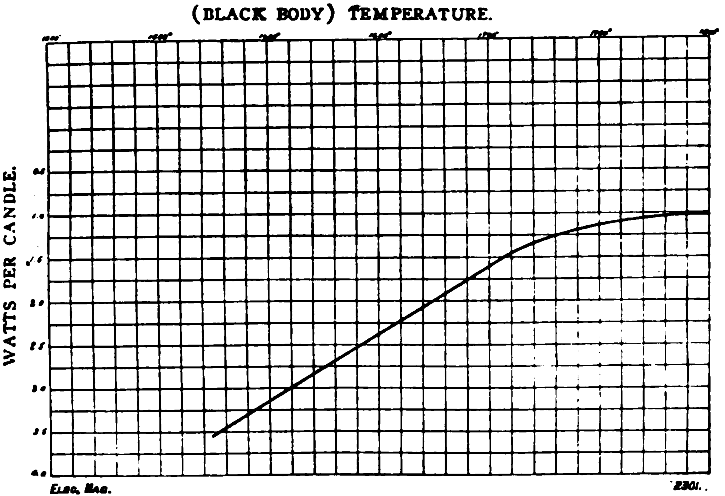

FIG. 1.—CONSUMPTION CURVE OF HELION LAMP.

corresponding carbon filament would still be black or showing only a faint red glow. As the temperature is increased the intensity of the light increases, as does also the efficiency.

In Fig. 1 is shown a curve giving the relation between the watts per candle and the temperature of the filament measured by means of a Fery pyrometer. In this instance the efficiency increased until it reached nearly one watt per candle at 1800deg. (black body temperature). It was found that if the temperature be carried still higher that the efficiency per candle decreased; in fact, the candle-power of the lamp seemed to be independent of the temperature at higher points.

The temperature-resistance coefficient is shown in Fig 2, which is the result of tests on two lamps, the readings of which agree closely.

It will be noted that this coefficient is negative in this instance from 1125deg. up to 1350. From this point it becomes positive and increases slowly up to about 1720deg., at which point there is a kink in the curve, and beyond this there is a slight decrease. On account of this kink it was decided that the proper temperature for that particular lamp would be a little under 1720deg., so as to take advantage of the slight inherent regulation of the filament at that temperature. Two or three times the normal current may be passed through these filaments without destroying them. In one case a short piece of filament was mounted on copper leads in a bulb, and current was then passed through until one of the copper wires was fused. The filament showed no effect of the treatment; in fact, it is said that none of these filaments has been burned out: their destruction has always taken place by breakage, which occurs generally near to the leading-in wires or at the anchor, and is thought to be due to the strain set up at that point by the vibration of the filament and the anchor. A new method of anchoring has been devised by Mr. Clark, which, it is believed, will avoid this strain. In mounting the filaments in the bulbs it is very necessary to set them up in exactly the

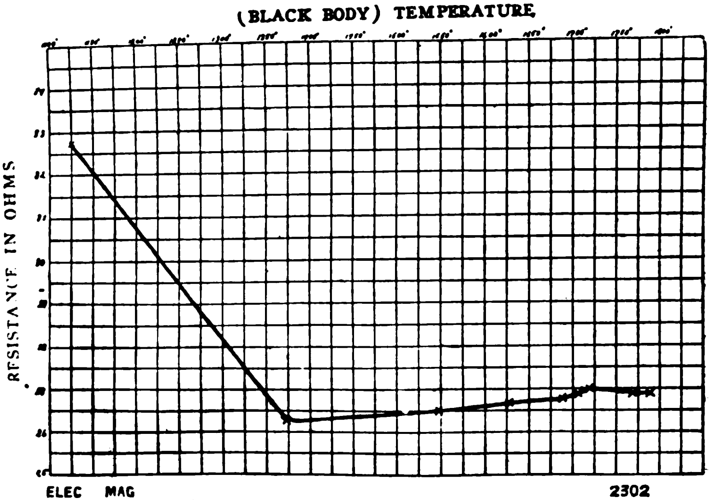

FIG. 2. TEMPERATURE COEFFICIENT OF HELION FILAMENT.

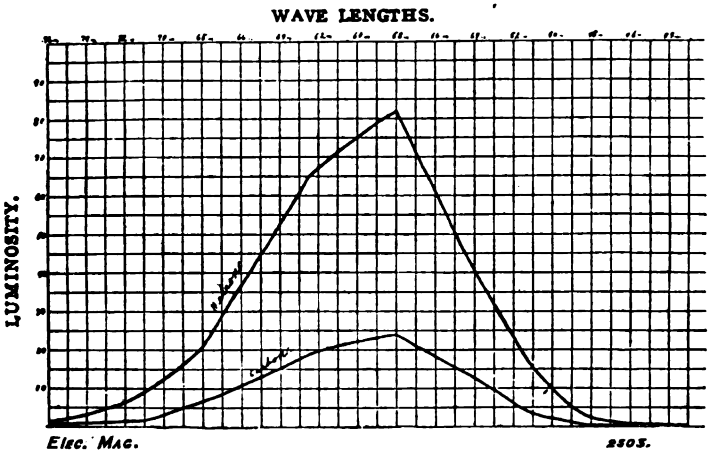

FIG. 3. RELATIVE INTENSITY OF LIGHT FROM HELION AND CARBON FILAMENTS.

shape which they normally take, in order to avoid this strain.

The metallic nature of the surface of the filaments has been demonstrated by the fact that after breaking they may weld together if brought into contact.

The character of the spectrum is shown in Figs. 3 and 4. Fig. 3 shows two curves, one being for a helion incandescent, and one for an ordinary carbon filament; while Fig. 4 gives corresponding curves for the relative energies of the helion and incandescent filaments. It would seem from this that although the helion filament was taking considerably less energy than the carbon filament, it was giving several times more light. These curves seem to show that the efficiency of the helion filament is due to selective radiation, a greater proportion of its energy being given out as luminous rays when compared with carbon; and this proportion holds closely throughout the entire visible spectrum. Upon this phenomenon depends the white character of the light.

The general form of the lamp resembles closely the ordinary carbon filament lamp; in fact, the only apparent difference between the two is the intensity and whiteness of the light given by the Helion filament.

During certain tests of these lamps it was observed that when an irregular deposit was produced, by some accident or purposely, that these enlarged portions of the filament showed apparently the same intrinsic brilliancy as the thinner portions; in fact, projecting spurs have been purposely produced, which, under normal running, glowed brightly out to the extreme tip. It was further observed that an increase in the efficiency of the lamp could be secured by carrying it to a temperature higher than that at which it is intended to run. Carrying the filament over 1800deg. seems to produce a sort of tempering which gives the lamp a set. Variations in temperature after this produce no further effect. Although no particular effort has been made to produce small units, it is thought that there will be no difficulty in making 30c.p., 110-volt lamps. Probably lamps of considerably less candle-power can be made. As mentioned above, conclusive figures for the life of the lamp are not yet available. These experimental lamps have been exhausted at the laboratory, where the facilities for this purpose are not of the best. It is thought that better results will be

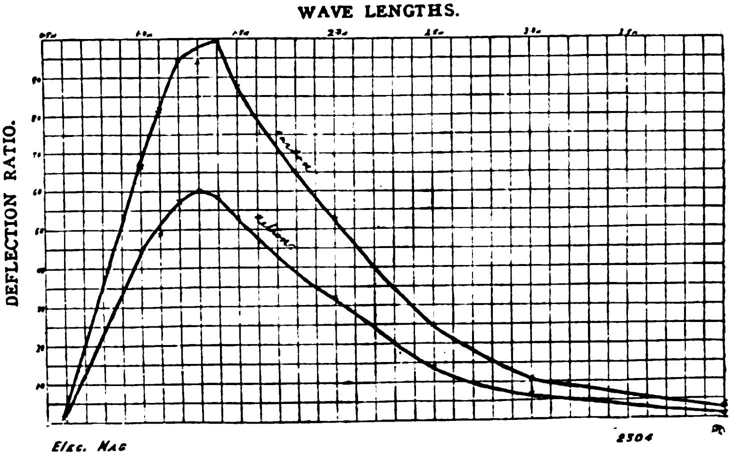

FIG. 4. RELATIVE ENERGY FROM HELION AND CARBON FILAMENTS.

obtained when improved methods of exhaustion which have been devised by Mr. Clark are put into operation.

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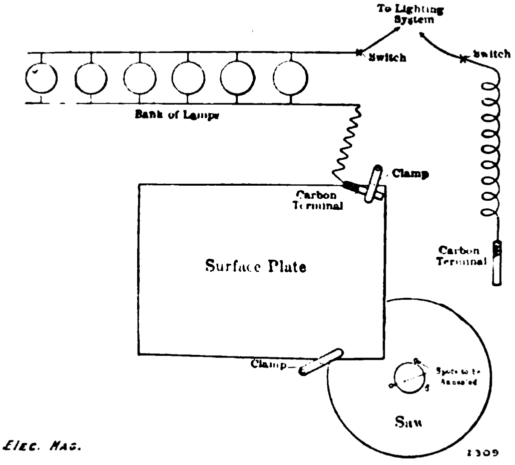
Saw Annealing by Electric Arc.

L. L. ARNOLD.

In a letter to the *Electrical World* the author describes how in a simple manner he utilized the electric arc for annealing the centre of a circular saw. Having been faced with a milling operation that required the use of a 4in. saw $\frac{1}{16}$in. thick very close to a projection on the work, so it could only be supported on one side, the author made a special arbor, turned a shoulder $\frac{1}{32}$in. longer than the saw was thick and soldered the saw in place; but the heat of the solder made the saw buckle and it would break loose after milling a few pieces. Then he decided to anneal the centre of the saw and fasten it on to the end of the arbor with button head screws, and after several attempts with the gasoline torch succeeded in cracking the several saws on which the work was being done. After this he began to experiment with the electric arc. An appliance had already been fixed up for a different kind of job, consisting of two pieces of arc light carbon connected up to the lighting system, which was 110 volt direct-current, with a bank of six 16c.p. lamps arranged so one or more could be put in circuit for resistance. First the spots to be annealed were marked on the saw, which was then clamped by one edge to a small surface plate. One of the carbon terminals was also clamped to the surface plate, and turning on the current the other carbon was held just far enough from the spot to be annealed to cause a good arc. This was continued until the spot was judged to be hot enough, and then the other spots were treated in the same manner. The result was so successful that the saw was easily drilled and countersunk at the annealed spots and the screws let in flush with the side of the saw. This time the work was finished without further trouble.

The diagram herewith illustrates the general arrangement of the apparatus used and the method adopted.



SAW ANNEALING BY THE ELECTRIC ARC.

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Cooper Hewitt Lamps in a Steam Room.

An interesting application of Cooper Hewitt mercury vapour lamps is found in the lighting of large rooms filled with steam, where the feeding mechanism of arc lamps is often a source of trouble.

In a large hat-factory twelve of these lamps are installed, two in series, on 220 volts, direct current. Each of these lamps gives light from a tube 45in. long and 1in. in diameter. With the standard reflector the average candle-power measured from the horizontal is as follows:

At	30 degrees......	800 candle-power.
	45 degrees......	955 candle-power.
	60 degrees......	1100 candle-power.
	90 degrees......	1200 candle-power.

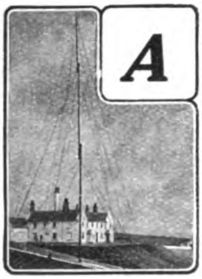
Each Cooper Hewitt lamp consumes 385 watts, or a total of 4620 watts for the twelve lamps. This gives .64 watts per square foot of floor space lighted. Twenty-four arc lamps, taking 660 watts each, a total of 15,840 watts, or 2.19 watts per square foot floor area, were formerly used.

It will thus be seen that the current consumption has been reduced to twenty-nine per cent. of the amount formerly required. In other words, there is a saving in current of seventy-one per cent. In addition to the saving in current, and of much more importance, it is stated that the production of the men in the room has been increased, due to the better quality and more even distribution of the light.

TELEGRAPHY & TELEPHONY

For titles of all important Telegraph and Telephone articles of the month, see World's Electrical Literature Section.

A New System of Telegraphy.



A NEW system of telegraphy has been invented by Stephen D. Field, the well-known telegraph engineer. The new system is a modification of the Morse, and is, the inventor believes, the final step in its development. In the Morse system of transmission the relays at each station are operated directly by the current from a battery which flows through the line when a key is closed. The strength of the current at each relay, and hence the sharpness of the signals, depend, of course, upon the voltage employed and the electrical constants of the line. But they also depend upon the goodness of the line insulation, and in bad weather so much leakage may take place that it will be impossible to obtain sharp signals; the relays respond slowly and transmission is tedious and difficult. Mr. Field's new system is designed to overcome this trouble and render the line independent of the weather and other factors having a similar influence. It has given beautiful results on an artificial line purposely made as bad as possible.

In the new system of Morse transmission advantage is taken of the idle time occupied by the spaces in the alphabet to store up, at each station where the transmission key is being manipulated, a small amount of energy from the line battery and relay discharge currents, said energy being utilized in the formation of the next succeeding dot or dash. The result is accomplished by means of an induction coil and condenser arranged to bridge the signal key.

When the key is open a condenser is charged through a heavy impedance which is formed by the primary of an induction coil, the secondary of which is included in the line circuit. On closure of the key the energy stored in the condenser acts inductively upon the primary winding, setting up currents in a direction to assist the line battery in its work. As a result of this arrangement all the relays in the circuit respond firmly and quickly to the key movements, no matter how "high" their adjustment, and it becomes possible to work circuits at full speed during stormy weather, which, under old conditions, could only be operated very slowly or not at all.

The diagram, illustrating one form of the arrangement, is as follows :—

Opening the key C a current from the line has a tendency to charge the condenser; it is met, however, by the immense impedance of the coil B, which should equal the drag of all the other apparatus in the circuit; a prompt break of the line current

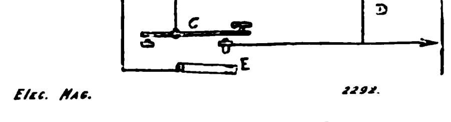


Diagram of Connections—Field System.

is thereby assured. On closure of the key the condenser discharge, in circulating through the convolutions of coil B, induces currents in coil A of the proper direction to assist momentarily the line current.

By this means a phantom line battery is provided at every way station on the line, resulting in greatly increased working margin on the whole circuit. When used on short circuits the condenser B is sometimes omitted, the magnetic charge acquired by coil B having been found sufficient. When the key is at rest the switch E shunts the whole arrangement from the circuit.

Many modifications of this arrangement have been devised and completed, such, for instance, as making the relay act as an inductorium, using extra windings on supplemental core extensions for the purpose; but in universal application the arrangement illustrated will probably be found most suitable, as it involves no change in existing apparatus and adds nothing liable to go wrong to the circuit.—*Elec. Rev.*, *N. Y.*

Sustained Electrical Oscillations.

An interesting application of mercury vapour converters to wireless telegraphy is disclosed in two American patents recently issued to Mr. Frederick K. Vreeland and described in a recent number of *The Electrical World and Engineer.* In order to be able to feed energy into the circuit constantly or at intervals in synchronism with the oscillations so as to supply that lost in radiation and otherwise, the inventor employs the effect of a magnetic field upon sensitive gaps formed by current passing through a mercury vapour tube. In the accompanying diagram (Fig. 1), which illustrates one of the arrangements proposed, the mercury vapour tube has two anodes and a single mercury cathode, a source of direct-current being connected from the cathode to the anodes by two branches containing a condenser, and two deflecting field coils are shunted across the anodes. For simplicity of illustration the field coils are shown with their axes in the plane of the anodes, while in practice they are placed in a plane perpendicular to that in which the anodes are located, so that the magnetic flux will be perpendicular to the plane of the anodes.

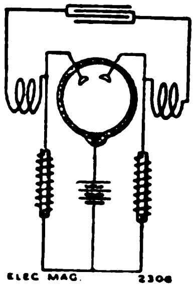


Fig. 1. Apparatus for Producing Sustained Oscillations.

When the apparatus is started the current tends to divide equally between the two parallel paths, but there is always some variation in the distribution due to variable inequalities in the conductivities of the two paths. This is especially true when a mercury vapour tube is used. These irregular fluctuations are sufficient to start the oscillations, after which they give place to the periodic fluctuations controlled by the alternating field. When the magnetic field deflects the current in the tube, from one anode to the other, the tendency is for the current in both branches to pass wholly or largely through the tube from the latter anode to the cathode, due to the fact that the path through the tube from the former anode to the cathode is interrupted or increased in resistance by the deflection of the current towards the other anode. As the inductances oppose any change in the current passing through them, this results in the current in the branch flowing through the oscillating circuit from left to right, including both field coils, thereby producing a field which still further deflects the current from one anode to the other. When the condenser is charged to the requisite potential, this current is checked and reversed, thereby producing a field in the opposite direction which deflects the current in the tube, so that the idle anode becomes active. In this energy is supplied to the oscillating circuit in synchronism with the oscillations. The frequency of these oscillations is dependent upon

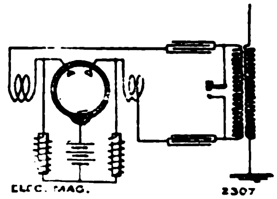


Fig. 2. Application for Telegraphy.

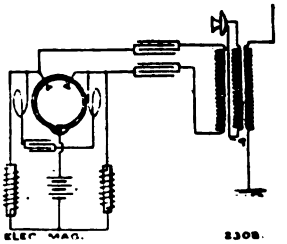


Fig. 3. Application for Telephony.

the constants of the oscillating circuit and may be changed by changing such constants.

Sustained oscillations are desirable especially in wireless telegraphy or telephony. A simple arrangement for wireless telegraphy is shown in Fig. 2. The oscillating circuit includes the primary of a step-up transformer, whose secondary is connected in series with the antenna circuit, which is suitably tuned with respect to the primary circuit. The radiation is made intermittent at will for the purpose of producing signals by means of a key which short-circuits the primary of the step-up transformer, and thus annuls its action on the antenna circuit. For wireless telephony use is made of the arrangement shown in Fig. 3, in which the working oscillating circuit is separate from the oscillating circuit which excites the field. The inductance is utilized as the primary of a step-up transformer, whose secondary is in the antenna circuit. The tertiary of the transformer is closed by a carbon telephone transmitter having a sufficient current-carrying capacity to answer the purpose.

Strength of Wooden Poles.

The Forest Service of the United States Department of Agriculture has recently conducted some valuable tests on the effect of duration of stress on the strength and stiffness of wood. It has been established that a wooden beam which for a short period will sustain safely a certain load will break eventually if the load remains. For instance, wooden beams have been known to break after fifteen months under a constant load of but 60 per cent. of that required to break them in an ordinary short test.

This relation of the duration of stress to the strength and stiffness of wood is now being studied by the Forest Service at its timber-testing stations at Yale and Purdue Universities. The investigation should determine: The effect of a constant load on strength; the effect of impact load or sudden shock; the effect of different speeds of the testing machine used in the ordinary tests of timber under gradually increasing load; and the effect of long-continued vibration.

The tests show that the effects of impact and gradually applied loads differ, provided the stress applied by either method is within the elastic limit of the piece under test. For example, a stick will bend twice as far without showing loss of elasticity under impact, or when the load is applied by a blow, as it will under the gradually increasing pressure ordinarily used in testing. These experiments are being extended to determine the general relations between strength under impact and gradual loads.

Bending and compression tests to determine the effect of the speed of application of load on the strength and stiffness of wood have already been made at the Yale laboratory. The bending tests were made at speeds of deflection varying from 2.3in. per minute to 0.0045, and required from twenty seconds to six hours for each test. The woods used were long leaf pine, red spruce and chestnut, both soaked and kiln-dried. The tests show concretely the variation of strength due to variations of speed liable to occur during the test itself. The results plotted give a remarkably even curve as an expression of the relation of strength to speed of application of load, and show much greater strength at the higher speeds. A numerical expression of the law, averaging all species, both wet and kiln-dry, gives the following table, which shows the increase in strength with the increase in speed of test:

Minutes to move crosshead 1in.	Ratios of ultimate Compression.	Strength Bending.
900	100	100
350	100.8	100.9
150	102.3	107.3
40	106 9	110.1
5	113.8	118.7

The first column, which gives the number of minutes required to move the crosshead of the testing machine over the space of 1in., is the reciprocal of speed. The second and third columns give the effect of this increase of speed upon compression and bending respectively, and show that strength increases with speed. The strength at the lowest speed is arbitrarily fixed at 100 as a convenient basis for comparison. The ordinary bending-test speed for small specimens is $\frac{1}{10}$in. per minute, or, reciprocally, 10 minutes are required to move the crosshead 1in.

It is a common belief among polemen that the continual vibrations to which telephone poles are subjected take the life out of the wood and render it brash and weak. Nothing is definitely known as to the truth or falsity of this idea. Tests will be undertaken to determine the effect of constant vibration on the strength of wood.

ELECTRICAL DESIGN & Manufacture

Every aspect of the design and manufacture of electrical apparatus is dealt with in this section month by month, and Engineers connected with large manufacturing concerns are especially invited to contribute.

Estimation of Armature Diameter.

L. A. FREUDENBERGER.

In the design of a direct current machine, the determination of the proper armature diameter usually constitutes the first difficulty, since nearly all the other variables are influenced more or less by the value chosen for this. The armature diameter is usually determined by the following empirical relation:

$$W = k\, l\, d^2 n, \qquad (1)$$

where W is the output of the machine in watts,

- l is the length of the armature in inches,
- d is the diameter of the armature in inches,
- n is the speed in revolutions per second,
- k is a constant, usually denoted by the "output coefficient" which varies with both the type of design and the output.

Equation (1) is not wholly empirical, as shown by the derivation of the following (equation 2).

Let B be the magnetic density in the air-gap, in lines per square inch, just outside of the armature surface.

Let $\%$ be the percentage of armature covered by the poles.

Then $\pi d l$ is the outside cylindrical surface of the armature in square inches.

$\% \times \pi d l$ will represent the area of that portion of the armature surface into which magnetic flux passes from all of the poles, and

$\% \times \pi d l \times B$ will be the number of lines which are cut by a single conductor on the armature in one revolution.

Further:

$\% \times \pi d l \times B \times n$ will give the number of lines cut per second, or the voltage generated per conductor; where n is the speed in revolutions per second.

In volts, the generated e.m.f. per conductor will be

$$\frac{\% \times \pi d l \times B \times n}{10^8}$$

For the purpose of obtaining the total power generated in the armature independently of the number of paths and the number of conductors, the current output may be expressed in terms of the total number of ampere-conductors on the armature. The armature power can thus be assumed to be generated by all the conductors connected in parallel (one single conductor, carrying a current of $Z I$ amperes; where Z is the total number of armature conductors and I is the current in each conductor).

The power generated in the armature is thus:

$$\frac{\% \times \pi d l \times B \times n \times Z I}{10^8}$$

In a design, the output of the machine, W, would be known. Estimating the electrical efficiency, $\epsilon = \dfrac{W}{W + R I^2}$, where R is the resistance of the armature, the armature power can thus be determined with fair accuracy. Thus

$$\frac{W}{\epsilon} = \frac{\% \times \pi d\, l \times B \times n}{10^8} \times Z\, I, \qquad (2)$$

where W is the output expressed in watts.

An estimate of $Z\, I$ in terms of the armature diameter can then be made by assigning a value to the number of ampere-conductors per inch of periphery, c, on the armature circumference.

The total number of ampere-conductors, $Z\, I$, is thus:

$$c \times \pi d = Z I$$

and equation (2) becomes

$$\frac{W}{\epsilon} = \frac{\% \times \pi d\, l \times B \times n}{10^8} \times \pi d \times c. \qquad (3)$$

Equation (1) can thus be obtained from the more general equation (3) by grouping all the constants in (3) into one constant, k.

The ampere-conductors per inch of circumference, c, among commercial machines will vary from 200 to 600 and will depend upon the output and type of machine, the constant being highest for large well-designed machines.

The value of the constant, c, to be chosen depends primarily upon the economy with which the winding space can be filled up by active conductors. For this reason, the constant for surface-wound armatures will usually be higher than for slot-wound armatures of the same capacity, and will usually equal, or perhaps exceed, the limiting value (600) for the largest sizes of surface-wound armatures (100 to 200kw.).

In large sized bar-wound armatures, where the conductors are embedded in slots, a large proportion of the winding space is filled up by "active" conductors; that is, the "waste" space is reduced to a minimum. For the large sizes of slot-wound armatures, the constant, c, usually does not exceed 550.

On the very small sizes of machines (1kw. or lower), where there is a large proportion of "waste" space, the constant, c, would usually be considerably below 200.

The value of the constant depends to some extent also upon the allowable temperature rise of the armature. For machines with a large overload capacity, the circular mils. per ampere of a conductor must be made high, thus necessitating more winding space and a lower value of the constant.

Should the constant, c, be chosen too high, it will be found impossible to get the conductors and their insulation in the winding spaces.

The percentage of armature covered by the poles will usually vary from 60 to 80.

The density in the air-gap, B, will vary with the material of the poles, and with the type of design. For instance, if the poles are entirely of steel, the density in the air-gap may be run as high as forty to fifty thousand lines per square inch. A "stiff" field is advantageous in reducing weight and eliminating sparking.

The speed, n, would always be known in a direct-connected set. In the case of a belted machine, or where the speed is not otherwise determined, the speed is fixed by the greatest peripheral velocity of the armature. The peripheral velocity ranges from 3000ft. to 5000ft. per minute for belted machines, being greatest on the larger sizes. The peripheral velocity for a direct-connected set usually does not exceed 2500ft. per minute.

Then

$$v = \frac{\pi d}{12} \times n \times 60 = 5\, \pi d\, n$$

or

$$n = \frac{v}{5\, \pi d} \qquad (4)$$

where v is the peripheral velocity of a point on the armature surface, in feet per minute.

If the speed is not given from the elements of the design, the speed, n, to be used in equation (3) is then determined from (4).

In order to evaluate d it is necessary to assume a value for $\frac{l}{d}$; that is, the ratio of the length to the diameter of the armature. If this ratio is considered empirical, its value is determined from experience. In multipolar machines the armature diameter is usually so chosen that the pole-pieces are about square; that is, so that the field coils may be wound almost circularly, and thus economize in the copper needed for the field coils.

If the field poles are about square, then the arc along a pole face is approximately equal to l, the length of the armature. Thus,

$$l \times P = \% \times \pi d,$$

where P is the number of poles.

Therefore, $$l = \frac{\% \times \pi d}{P}$$

Thus equation (2) is reduced to an equation containing d, the armature diameter, as the only unknown term.

With a few changes, equation (2) can be adapted to an alternator.

For a sine wave of e.m.f., the flux density in the air-gap may be assumed to decrease uniformly on a sine curve of space distribution from a maximum, B, under the middle of a pole, to a minimum, zero, between the poles. Then the *effective* e.m.f. for a single conductor will be

$$\frac{\% \times \pi d l}{10^8} \times \frac{B}{\sqrt{2}} \times n,$$

since the ratio of effective to maximum, for a sine curve, is $1/\sqrt{2}$.

For a distributed winding this e.m.f. equation must be corrected by the form factor, F, since in a distributed winding there are conductors connected in series which have not their individual e.m.f.'s exactly in time phase with each other.

This e.m.f. per conductor is then multiplied by ZI, the effective ampere-conductors, to give the volt-amperes generated in the armature. In designing for an inductive load, the volt-amperes are multiplied by $\cos\theta$ (power factor) to give the output in real power; where θ is the angle between the e.m.f. and the current.

The complete equation for the alternator is thus:

$$\frac{W}{\epsilon} = F \cdot \frac{\% \times \pi d l}{10^8} \times \frac{B}{\sqrt{2}} \times n \times Z I \cos\theta. \qquad (5)$$

The advantage of using equation (2) and its derivatives rather than equation (1) is that the single factor, k, in equation (1) is resolved into its component parts—whose limits are better known.—*Elec. World.*

Method of Drying-Out Plant.

S. L. SINCLAIR and E. D. TYREE.

THE power house of a large eastern manufacturing concern was recently flooded with water to a height sufficient to cover the two turbo-generators, two-thirds of the switchboard, and a large part of the auxiliary apparatus, including the exciter units and the condenser pump motors. The writers were called upon to get the plant in operating condition again with the least possible delay. Upon arriving at the power house it was found that the employees of the local company were attempting to dry out the generators by the use of a steam coil enclosed in an air flue. A blower was connected at one end of the flue and the other end opened at the generators so that the hot air could be blown through the generator windings. This method would have taken an infinite time to dry out the generators. It was therefore abandoned and an enclosure of sheet iron and tin, that was found around the works, was built up around the generators. Inside this enclosure were placed a number of charcoal furnaces made of powder kegs. Thermometers were suspended near the generators, and the temperature inside the enclosure was maintained at 85deg. C.

While the generators were being dried by this process a small hoisting engine was belted to a 20h.p. motor for use as an exciter. Arrangements were also made with the local railway company to furnish 500-volt direct-current for making tests of insulation resistance. Insulation tests were made with a 600-volt direct-current motor having an internal resistance of 85,000 ohms.

After the generator had been drying for thirty-six hours the insulation resistance was about half the normal value. The generator was then started on a short-circuit heat run, and at the expiration of thirty hours, making sixty-six hours in all, the readings showed that the insulation was thoroughly dry and the generator was ready to go into service.

The second generator was dried in the same manner with equally satisfactory results. The motors, exciters, and switchboard were dried by the use of charcoal furnaces.—*The Electric Journal.*

The Treating of Transformer Oil.

S. M. KINTNER.

It is generally known that the presence of water in oil is detrimental to its insulating qualities, yet it is hardly appreciated how slight an amount of water or moisture is required to very materially reduce the dielectric strength of oil. There have been a number of instances where careful chemical analysis failed to show the presence of moisture, when an electrical test indicated its presence, this fact being established by retesting the oil after the removal of the moisture.

It is a simple matter to tell whether the oil has moisture, provided there is very much water present, as it will readily settle out in the bottom of a sample drawn from the lowest point of the transformer. Another test that is more sensitive, and is, in fact, amply sensitive for a large majority of cases, is to thrust a red-hot nail or rod into a sample of oil under test. If the oil "crackles" like frying grease, water is present. In the absence of moisture there will be no crackling sound when the rod is thrust into the oil. In the electrical test of dielectric strength, average dry oil should not be weaker than 30,000 volts as the mean of ten tests for a 0.15in. gap between one-half inch spheres. The oil should not break below 25,000 volts in any of the ten tests.

There are six ways of effecting the separation of oil and water—(1) mechanical separation, (2) capillarity, (3) electro-static force, (4) heating, (5) vacuum and heating, and (6) dehydrating.

Mechanical Separation.—When the oil contains considerable water or moisture, its greater density will cause a separation between the two materials, the water settling to the bottom. After this separation, the excess water can be readily drawn off. The same separation can be effected by passing the material through a centrifugal machine. The water in this instance will settle to the outside, and can be drawn off. As the amount of drying that can be effected in this way is not sufficient for the higher voltage work, this separation needs to be followed by some more complete method of drying.

Capillarity.—During the development of an oil-treating outfit, the fact was noted that certain materials had the property of allowing the water to pass through readily but still interfering with the passage of oil, this action being due, it is believed, to the difference in capillary attraction of the two materials. This fact has been made use of in a form of a separator which allows the passage of water and still retains the oil, this separator being in the form of a disc, and placed so that all water and oil passing to the treating outfit passes over the disc. The disc allows the separation of the excess water and consequently relieves the treating outfit of a certain amount of work. The separation that is effected by this method is, however, of the same order as that mentioned under the heading of "Mechanical Separation," and the oil needs further treatment before it is sufficiently dry for good electrical service.

Electro-static Force.—An intense electrostatic field can be so arranged that it will tend to hold the water, and impurities of higher specific inductive capacity than the oil, in its denser field. This effects a certain separation, permitting the dry oil of lighter specific inductive capacity to pass to the weaker side of the field. By drawing off the oil from these several points, it is possible by repeating the process several times to effect a drying of the material. Tests that have been made on this method, while indicating the possibility of its being used, have not shown it to be entirely satisfactory. As a rule it will be found difficult to operate such an arrangement, and it is on the whole not to be recommended.

Heating.—Moisture can be removed from oil by direct application of heat. This can be brought about in several ways, one of the most common of which is to immerse in the oil grid resistances which are heated electrically. The oil as a whole has its temperature raised slightly above the boiling point of water, and it is maintained at this temperature until the moisture is boiled out. The grid resistances should be placed at the lowest possible point in the oil, as otherwise all oil below these resistances will remain cold and there will be an accumulation of water at this point, with the result that if all of the oil is drawn off at the end of the drying, this moisture will be mixed in with the oil that has been dried above the grids. It is much better, if possible, to so arrange the drying tank that the heat is applied below the tank. In this manner all of the oil that is being dried is subjected to the heat. It is necessary to maintain a temperature of 105° to 110° C., and this will have to be maintained until tests show that the oil has been entirely freed from moisture. As a rule, in drying large quantities of oil, this will require from ten days' to two weeks' heating. The continued heating of the oil at this temperature will prove very detrimental to the oil. It will tend to break it up, separating the lighter hydro-carbons and causing certain formations in the oil due to this separation. Oil that has once been overheated in this manner is apt to continue to develop this formation when put in service and operated at lower temperatures. The oil will be greatly changed in colour, being very much darkened. On account of the change in the oil, this method is not looked upon with much favour, and should be used only in cases where other apparatus for drying the oil is not available.

Another method of applying the heat is that of blowing hot air through the oil. In doing this it is necessary to be sure that all moisture is removed from the air that is being blown in, as otherwise the hot air will carry in moisture and condense it in the oil, thus adding to the amount of moisture in the oil rather than taking it out. This method is open, of course, to the same objection as that raised to the above, that of causing decomposition of the oil. It is believed to be somewhat worse than direct heating, as the great amount of air blown in will cause a certain amount of action which is apparently a form of oxidation, and will aggravate the decomposition of the oil and the settling out of the lighter hydro-carbons.

Vacuum and Heating.—It has been found possible to dry oil by the use of a vacuum tank, heat being applied to the oil at the same time. The use of a vacuum lowers the boiling point of the water and consequently makes it possible to eliminate the moisture without reaching a temperature that is detrimental to the oil. This method, where available, should prove satisfactory, and it is possible to secure an oil that is perfectly dry by this treatment. As a rule, it will require considerable time to thoroughly remove the moisture, and for this reason the method is not as convenient as the one described below.

Dehydrating.—Moisture can be removed from oil very rapidly and very cheaply by the employment of suitable agents for absorbing the moisture. The engineers of the Westinghouse Company have developed a treating outfit which employs this principle, in conjunction with method (2) described above. This outfit circulates the oil to be dried through a treating tank in which is placed a dehydrating material. The oil, after passing through this dehydrating chamber, is filtered, and thus all foreign materials that are in the oil, as well as any of the dehydrating material that may have followed through, are removed. It has been found possible with an outfit of this kind to dry a thousand gallons of oil in a day, and to have this oil as dry as is required for the highest voltage service. Lime is the material employed in the dehydrating tank. This material has been selected as it is usually available and introduces no possibility of injuring any part of the transformer if any of it gets through the filter with the oil. It has the additional advantage of tending to neutralise any acids existing in the oil. Sand has generally been used for the filtering, although in some instances it has been found advantageous to mix in certain proportions of bone-black and Fuller's earth, these last two having the property of tending to clear the colour of the oil.

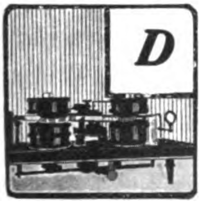
It is the writer's opinion that the last method mentioned will be found much superior in general practice to any of those mentioned above. The outfit that has been developed is portable, and is a compact unit in itself, being provided with a motor and pump, together with the necessary filtering and treating tanks and accessories. The oil should be tested from time to time to see that the dehydrating materials have not depreciated in strength. When the oil indicates this fact, it is necessary to re-charge the apparatus. No statement can be made as to how much oil can be treated with one charge, as this is dependent upon the amount of moisture held in suspension in the oil, which will vary with different oils and temperatures. It is quite probable that the companies operating the extremely high voltage transmission systems will find it necessary to treat the oil used in the transformers, switches, &c., periodically, so as to insure its being in the best possible condition. For such service as this, an outfit of the kind just described is very effective.—*The Electric Journal.*

ELECTRO-CHEMISTRY, Electro-Physics and ELECTRO-METALLURGY

Titles to all important articles on the subjects covered by this section will be found in the World's Electrical Literature Section.

*The Standard Cell.**

F. A. WOLFF and C. E. WATERS.



DURING the past year considerable work has been done at the Bureau of Standards to obtain data to serve as the basis of specifications for the construction of both Weston and Clark standard cells. While much still remains to be done, considerable experimental material has been gathered on the accuracy with which it is possible to reproduce these standards. The results of this work are submitted in abstract; full details will, however, be given shortly in the *Bulletin* of the Bureau of Standards.

Efforts were first directed to the preparation of mercurous sulphate of uniform electromotive properties for which the following methods were employed:

1. The electrolytic method, developed in 1904 by one of the authors and also independently by Carhart and Hulett. In this method the mercurous sulphate is formed at a mercury anode in sulphuric acid. Thirty-eight samples were prepared with current densities ranging from less than 0.1 to more than 9 amp. per sq. dm., while the concentration of the sulphuric acid varied from 20 to 400 grams per litre.

The samples were made between 1904 and 1906, and two different forms of apparatus were employed.

2. By the recrystallization of "c.p." samples purchased from various manufacturers, from strong sulphuric acid.

3. By the action of fuming sulphuric acid on mercury.

4. By the action of sulphuric acid on mercurous nitrate.

5. By the reduction of mercuric sulphate by mercury.

6. By the reduction of mercuric sulphate by sulphurous acid.

7. By the direct action of sulphuric acid, containing a small percentage of nitric acid, on mercury (Lunge reaction).

8 and 9. Two electrolytic samples obtained from Dr. Hulett.

10. By digestion of "c.p." samples with hot 1 : 4 sulphuric acid.

11. By digesting "c.p." samples with 1 : 4 sulphuric acid since 1904.

12. Same as 11—other samples.

13. By digesting "c.p." samples with 1 : 6 sulphuric acid since October, 1905.

The electromotive properties were tested by setting up at least one Clark and one Weston cell for each sample.

The remaining ingredients were carefully purified, and when different samples of the same material were employed, check cells were always set up to test for any variation which might thus be produced.

Between three and four hundred cells have already been set up. They are all of the H type, hermetically sealed, and are compared under oil in specially constructed electrically-controlled baths in which the temperature may be kept constant well within .01 deg. C.

Cells of the same type were compared at

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* Abstract of paper read before the Am. Phys. Soc., N.Y., Dec., 1906.

frequent intervals by measuring the e.m.f. of each cell in opposition to one selected as a comparison standard, so that the results could readily be expressed in terms of it or any combination of cells measured. The values obtained from day to day generally agree to within a few parts per million, and although most of the Weston cells of the bureau are seven months old no tendency for a decrease in e.m.f. as observed by Hulett has been found. A small number of cells which showed high initial values have decreased, but not below the mean of all the cells made with electrolytic mercurous sulphate. The same remark applies to samples made by the various chemical methods employed.

In addition the ratio of Clarks to cadmiums was determined from time to time, but the small differences observed, amounting to from two to three parts in 100,000, and which include errors of temperature measurement and those due to defective insulation of the cells in the bath and between the individual coils of the high-resistance potentiometer employed, indicate an apparent decrease of the Clarks or an increase of the Westons.

A considerable number of Weston cells recently set up have somewhat smaller values of e.m.f. than those first set up, but the difference does not exceed 10 microvolts. The table below gives the results for all the cells set up for studying the influence of mercurous sulphate. The differences are expressed in microvolts and the mean e.m.f. of all the cells made with electrolytic sulphate is taken as a standard of reference.

Clark and Weston cells have been exchanged with Prof. Hulett, and very recently with Prof. Carhart and Prof. Guthe. In addition four electrolytic Weston cells made at Cornell University by Mr. Wold have been compared at the bureau. The results of these comparisons are given below in terms of the means of the bureau cells.

	WESTON CELLS.		CLARK CELLS.	
	Cell.	Mean Difference in Microvolts.	Cell.	Mean Difference in Microvolts.
Prof. Hulett....	A_3	+45	H_4	−15
,, ,, ...	A_{32}	+27	H_{18}	+ 5
,, ,, ...	O_4	40		
Prof. Carhart ..	No. 5	+ 1	C_2	00
,, ,, ..	No. 8	+ 4		
Prof. Guthe	Cl	+25	Al	+65*
Mr. Wold......	No. 24	− 9		
,, ,, ...	No. 27	−10		
,, ,, ...	No. 20	−24		
,, ,, ...	No. 21	−15		

* Approaching normal value.

While the direct comparison of cells made by Prof. Hulett with those made at the bureau shows a discrepancy of from 25 to 45 microvolts, cells made by the authors with sample No. 9 of mercurous sulphate

WESTON CELLS.					CLARK CELLS.		
Method.	No. of Samples.	No. of Cells.	Range.	Mean.	No. of Cells.	Range.	Mean.
			Microvolts.	Microvolts.		Microvolts.	Microvolts.
1	38	50*	+20	00	51**	+20	00
2	5	5	+ 1 −26	−12	5	+ 4 −22	− 9
3	1	1	−4	− 4	1	−2	− 2
4	2	5	− 7 −21	−16	2	0	0
5	2	2	− 10 −12	−11	2	0 − 9	− 4
6	2	3	+ 38 −19	+ 4	2	+ 5 + 5	+ 5
7	6	9	− 5 −23	−14	10	− 2 −14	−11
8	1	2	+ 34 +27	+30	3	+ 44 +23	+33
9	1	3	+ 3 − 5	− 1	3	+ 8 + 6	+ 7
10	6	6	+ 23 −17	+ 4	8	+ 44 − 1	+18
11	5	5	+ 55 + 1	+27	5	+ 67 +12	+37
12	4	4	+ 80 +22	+50	—	—	—
13	6	6	+117 +21	+70	8	+143 +60	+90

* 5 additional cells were set up.

Values. +42, +35, +23, −21, −27. Duplicates of 4 of these fall within the limits ± 20

The average deviation of the electrolytic cells from the mean of all the electrolytics is ±11 microvolts.

** 6 additional cells were set up.

Values. +36, +23, +22, −22, +33, +24. Duplicates of 4 fall within limits ± 20.

The average deviation of the electrolytic cells from the mean of all the electrolytics is ± 10 microvolts.

show that the differences are probably not due to a difference between the mercurous sulphate used, but rather to some difference in the other materials or to some difference in the specifications employed.

Samples of the various materials will, therefore, be exchanged to determine the cause of difference with other investigators in this field, and it is confidently expected that an excellent agreement can be reached by all when the same specifications are followed as is here shown.

A study has also been made on the electromotive differences of cadmium sulphate obtained from various makers or made directly from the "c.p." metal. Twenty cells set up with clear and cloudy crystals, obtained by the recrystallization of 8 samples, from acid, neutral and basic solutions, show an average deviation from the mean of all of + 9 microvolts and with a range of + 28 and − 26.

Further work is in progress on the remaining materials and on other factors which might influence the e.m.f.; that is, the size of grain, depth of paste, influence of diffusion, influence of added impurities and a careful determination of the temperature coefficients will be made.

The main conclusions to be drawn are that, since samples of mercurous sulphate of uniform electromotive properties can be made by a number of different methods, and since the remaining materials used in the construction of standard cells can be obtained in an exceedingly pure state, Clark and Weston standard cells are reproducible to within two or three parts in 100,000, that when set up with proper materials they reach a permanent value of e.m.f. within a few days, and the e.m.f. of the Weston cell can be depended on as constant well within the above limits for at least six months.

Another conclusion that might be drawn is that the standard cell has a marked superiority, both in ease and accuracy of reproduction, over the silver coulombmeter as a fundamental electrical standard, particularly as the results obtainable with the latter can be preserved only by the aid of a standard current balance, or the combination of a standard resistance and a standard cell, both of which must be assumed constant between silver coulombmeter measurements.

With materials at hand, and if necessary these could be procured by investigators from the various Natural Physical Laboratories, a number of cells can very readily be set up in far less time than that required for a coulombmeter measurement, and with a greater certainty of reproducing the volt than is possible by the coulombmeter and standard resistance, both of which are subject to error.

Moreover, the choice of the standard cell and the standard resistance as fundamental standard is the most logical, as practically all voltage and current measurements of precision are made by the potentiometer method, and thus directly in terms of the standard cell or the combination of a standard cell and a standard resistance.

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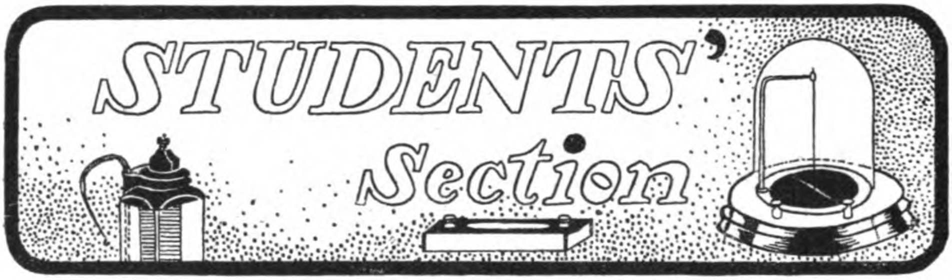
Development in the Electrical Manufacture of Steel.

It is reported from Prague that Austrian papers are discussing the introduction of the Kjellin process in the manufacture of steel by the Poldihütte, at Kladno, Bohemia, in concert with the Oberschlesische Eisen-industrie-Gesellschaft, which process, says the Prague *Tagblatt*, may bring about a complete revolution in the Austrian steel industry. Continuing, the Prague *Tagblatt* says:

That such steps may be leading to vastly important results may easily be realized when it is considered that the Kjellin process yields an excellent steel, said to be fully equal to the best crucible steel, while the cost of production is considerably lower than with the mode of production so far in use. The Kjellin product, however, apart from its lower cost, is further praised for its ductility, density, homogeneousness, softness, the possibility of obtaining high degrees of carboniferous quality, and, finally, for its excellent magnetic properties. If these surmises—as appears highly probable—should be proved by facts, all undertakings which have at their disposition the primary requisite for the adaptation of the electric process, viz., cheap electric power by means of sufficiently strong water power, will secure a great advantage over other works. Chief Engineer V. Engelhardt, in his work on the Kjellin process, states that it can compete with the Siemens-Martin, where the kilowatt-hour can be put down at about a farthing.



Students should refer to the World's Electrical Literature Section for classified list of articles of special interest to them.

Canada as a Field for the Electrical Engineer.

C. F. GRAY.

THE American Continent is large, but at the present time the stretch of country north of the forty-ninth degree of parallel, known as British North America, is perhaps the foremost in the world in its openings to the man of energy. Blest with a fine climate and a very productive soil, embracing in its arms a continual flow of humanity eager to wrest from nature its health-giving resources, the country is slowly but surely being filled by masses of people whose whole aim is to "get on." Such a concentrated mass of energy cannot fail to bring in its train the usual demand for labour—mechanics, skilled artisans, and engineers—to combat with conditions and overcome the difficulties always to be met with by the pioneer.

Electricity is now playing an important part in the development of Canada. In many of the provinces coal is high priced, but nature has come to the aid of the settler and provided some of the finest water powers in the world. Most of us have heard of and perhaps seen the huge power plants now running and in course of construction at Niagara, but not many, outside of those who know the country, have the slightest conception of the immense inherent resources of this vast land. British Columbia alone is blest with the finest water powers, for a country of its size, in the world; untold wealth in its mineral resources and coal is now being discovered; and, if you doubt its timber resources, go along the shores of Puget Sound and see the number of vessels of all nations loading British Columbia lumber. All winter long the woodman's axe can be heard ringing far up into the wilds, and in the spring a continuous stream of tamarack, pine, cedar, and hemlock is flowing to the coast to be shipped all over the world. The directors of many of the concerns handling the money-making resources of the country realize the saving to be gained in production by the use of electrical energy, and so a great many power plants are being built and projected, and the demand for electrical engineers is advancing.

The writer has in mind one plant which a few years ago was of about 6000h.p. capacity. Now the total capacity of the plant is about 30,000h.p. and the voltage has been increased from 20,000 to 60,000. This may not seem large when compared with the colossal schemes around Niagara, but when one remembers that this is only one instance of many, and compares the small population of British Columbia with the two millions in Ontario, it will be seen that the internal resources must be great indeed to allow of such developments. The territories are opening up, and, although Kipling in one of his poems states, "There's never a rule of God or man rules north of fifty-three degrees," the Northwest mounted police keep very good order, and business men have as much protection there as anywhere else. Saskatchewan, Alberta, Manitoba, Ontario, Quebec and the maritime provinces are all evidencing a desire for electrical development, and the need for men with initiative is growing.—*The Electric Journal.*

Three-Phase Power Measurement.

H. M. SCHEIBE.

THE fact that the power delivered to a three-phase circuit may be measured by two wattmeters is a matter of considerable importance and everyday application. The truth of the proposition, however, is usually demonstrated by mathematical treatment which, while conclusive, does not always give a practical understanding of what takes place.

It is the purpose of this article to offer a demonstration devoid of mathematics and applicable to any condition of unbalance of current or voltage. The proper connection of the meters is shown by Fig. 1, in which a delta-connected receiving circuit is assumed. The indications of the meters may be considered as made up of two parts, one due to phase A and B and the other to phase C. For clearness each part is dealt with separately, and the diagrams show only those circuits being considered at the time. Fig 2 shows phase C omitted.

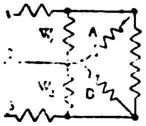


FIG. 1

Elec Mag

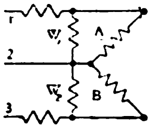


FIG. 2

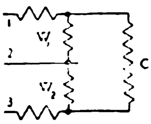


FIG. 3

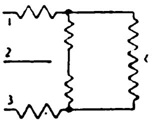


FIG. 4

2305

It is evident from this diagram that the power used in A and B will be indicated in meters W_1 and W_2 respectively, as A and B are simply two single-phase circuits with meters properly connected for reading single-phase power. Obviously then the sum of the effects of A and B on the meters will indicate the amount of power consumed in those two phases.

Having seen that the power consumed in A and B is recorded by the meters, the separate effect of C may be considered. Fig. 3 shows this part of the circuit, but before dealing directly with this case, assume as a preliminary step the connections shown by Fig. 4. Here the junction of the pressure coils of the two meters has been disconnected from line *2*, and it is evident that now *each* meter is connected to measure the power used in C except that the pressure coil of the other meter is in series with its own. This corresponds to connecting in a multiplier, and the indication of each instrument is reduced in proportion to the voltage across its pressure coil. So each meter will register a portion of the power in C depending on the proportion of the drop across C that takes place in the pressure coil. And, as the total drop in the two pressure coils must be the same as the drop across C, it follows that the sum of the effects of C on the two meters must represent the whole power consumed in C. This may be most clearly realized by considering *instantaneous values of voltage, current, and power*. By this means simple direct-current reasoning can be applied for any particular instant and the complexity of vector treatment avoided.

Reverting now to Fig. 3, in which the junction of the pressure coils is connected to line *2*, it will be seen that while this connection may disturb the division of drop, between the two pressure coils, it obviously cannot affect the total drop at a given instant, as this is, as before, equal to the drop across C. Hence it follows that the connection to line *2* may affect the distribution but not the sum of the effects of C on the two meters.

It has been shown above that the sum of the effects on the two meters due to A and B measures the power in A and B, and that the sum of the effects due to C measures the power in C. Therefore it follows that the sum of the combined effects of A, B and C must indicate the total power consumed in the three phases.

The foregoing has dealt entirely with a delta-connected circuit. The treatment, however, has been suited to any possible condition of voltages and currents on the three line wires, and it is these voltages and currents that determine the readings of the meters. Therefore this demonstration is applicable to all line conditions, regardless of the nature of the receiving circuit.—*The Electric Journal.*

◆

Dynamos in Parallel.

THERE are two features of paralleling electrical generators which nearly always puzzle the inexperienced operator: The effect of speed variation upon the load carried by either alternating or direct-current generators, and the impossibility of controlling the division of load between alternators by adjusting their field strength. The natural assumption, unless one analyzes the operation, is that if the speed of a direct-current generator decreases, more current passes through its armature because its e.m.f. is lowered and the e.m.f. at the bus-bars can therefore force more current through. A moment's reflection will show the fallacy of this reasoning. The current flowing through the armature is due to the e.m.f. generated by that armature, not the general e.m.f. at the bus-bars; therefore, any decrease in the generator's e.m.f. causes a decrease in the armature current and a consequent decrease in the load carried by it.

Of course an alternator working in parallel with other alternators cannot change its rate of revolution unless the majority of the others change theirs, because the rising and falling of the current locks all of the machines together electromagnetically. If the engine governor be adjusted so that the speed would be reduced if the machine were running free, the engine will deliver less power to the generator and the latter will consequently deliver less power to the bus-bars, compelling the other machines to make up its deficiency—assuming the total load to be constant—but the speed × magnet poles of the machine will remain the same as that of the other alternators.

With direct-current generators the result would be different in that the speed of the affected machine would drop when the governor adjustment for less power (shorter cut-off) was made. The machine would then deliver the correspondingly smaller power, like the alternator.

It will doubtless seem strange that a direct-current generator must decrease its speed to decrease its load (the field excitation remaining unchanged in both cases) while the output of an alternator can be reduced without changing its speed. The explanation is that when the engine is adjusted for less power, the alternator falls back slightly as to the relative position of its revolving member and that of the other machines, but continues to make the same number of revolutions per minute. The falling back puts it a trifle out of phase with the other machines—just enough for the armature e.m.f. to be neutralized by the bus-bar e.m.f. during a small part of each cycle. This neutralization reduces its delivery to the bus-bars.

From the foregoing it will be evident that the division of load between alternators in parallel may be controlled by adjusting the governors of the engines, but it is not shown why the same result cannot be obtained by adjusting the field excitation of the machines. It is not easy to explain fully what happens when the field strength is varied. When an alternator operating in parallel with other machines is carrying its proportion of the load normally, if its field excitation be decreased its voltage will be decreased, and its engine will speed up momentarily until the generator e.m.f. rises and falls a little in advance of that of the other machines; then there will flow between this machine and the others cross currents which will strengthen the field of the weakened machine and weaken those of the others. The results will be that the voltage of the entire system will be lowered slightly, the current delivered by the weakened machine will lag behind its e.m.f., and the division of load between the several machines will be practically the same as before, because the lagging current in the armature of the weakened machine will be increased. Strengthening the field of one machine will produce the opposite effects, of course.

When the voltage at a set of bus-bars requires adjustment, therefore, the field strength of every alternator connected to those bus-bars must be adjusted. This is made easy in practice by exciting the fields of all alternators in a station from a single direct-current source. Any variation of the voltage of this source produces a corresponding variation in the field excitation of all of the alternators. The excitation of each alternator is also adjustable individually, so that each machine may be made to work at its best.—*Power.*

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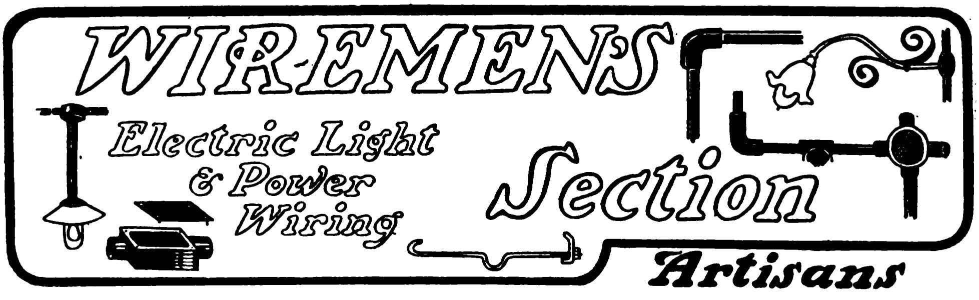


Wiring Work in Completed Fireproof Buildings.

T. W. POPPE.

It is often necessary in completed fireproof buildings to make extensions of circuits or change the outlets for electroliers to other parts of the ceiling. This work requires patience, skill, and a good general knowledge of the construction of the building.

The procedure in changing the outlets is as follows: The new positions are marked and the outlet boxes set. If the outlet is for a single lamp, only the box can be set with plaster of paris, a cavity being cut into the ceiling deep enough to allow the face or outside rim of the box cover to set flush with the ceiling. The box is then set or placed in the cavity, and the plaster is forced around it.

If an electrolier is to be suspended from the ceiling, a hanger must be provided. Where the flooring above the ceiling has been laid it is difficult to design a hanger that will hold the weight without cutting the flooring to insert it. Means must be provided to fasten a hanger securely in the ceiling without removing any flooring. For very heavy electroliers it is better to cut the flooring to place the hanger, a drop or threaded stem projecting through the ceiling. This hanger should be firmly cemented in place. For ordinary work the hanger shown in Fig. 1 has been found reliable.

The hanger is made up of two pieces of band iron bent as shown; holes $\frac{3}{8}$in. in diameter are drilled where indicated. The two band irons are then placed together at right angles, and locked with nuts and a piece of $\frac{1}{2}$in. pipe about 2in. long threaded its entire length. The lock nuts are firmly screwed against the band iron, and braces are then placed between the opposite sides of the hanger to hold the hanger rigid.

A hole the size of the box is next cut in the ceiling and gradually widened till it is three or four inches larger at the top than at the opening. The braces are then taken out of the hanger, the four prongs sprung together, the hanger placed in the hole and the braces replaced. The sides of the hole are sprayed with water till they are quite wet, and cement is forced into the remaining space, filling every crevice and thus imbedding the hanger. The hanger by this means becomes a part of the ceiling, and is practically just as strong.

When setting the hanger, space equal to the depth of the outlet box used should be left between the ceiling line and the bottom of the hanger. The box can be locked on the hanger by placing a lock nut inside the box, screwing it on the $\frac{1}{2}$in. nipple. Plaster of paris can be placed in the cavities surrounding the box.

Chases are then cut from box to box and the conduit run in the shortest line connecting them. The old outlet box is removed from the ceiling, and the conduit, if flexible, is joined to the conduit already in the ceiling by means of a combination coupling, one side being threaded for rigid conduit and the other moulded to securely hold the spirals of the flexible conduit. Such a coupling is shown in Fig. 2. If rigid conduit is used in making the extensions it is screwed to the conduit already in place in the ordinary manner. Circumstances do not allow this in all cases, and a running thread or right- and left-threaded coupling is used to connect them. A right and left-threaded coupling is preferable, as it holds the pipe or conduit more firmly than a running thread.

The conduit is fastened in the ceiling

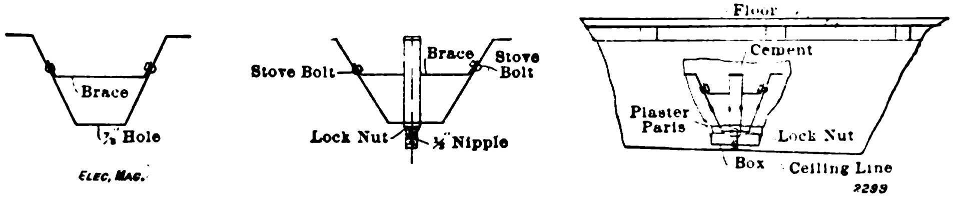


FIG. 1. DETAILS OF HANGER FOR CEILING FITTING.

chases by drilling holes ½in. wide and 3in. deep, and driving wooden plugs firmly therein. Eightpenny finishing nails are then driven into the wooden plugs and bent over the conduit, thus holding it in the chase. Wire nails are preferable to hooks, because of their smaller diameter and greater tenacity when driven in the wood. At least ¾in. should be allowed between the bottom of the conduit and the ceiling line. The chase is then filled with plaster of paris covering the conduit. The work thus becomes part of the ceiling. Outlets for brackets are replaced in the same manner, it being necessary to plaster the box in the side wall, using a fixture stud (Fig. 3) in place of a hanger.

It is sometimes desired to make extensions quickly and with a view to economy rather than permanency. In a case of this kind moulding can be used, and while not making as neat-appearing a job as that already described, would be passable when the corners are mitred and all joints well made. The moulding can be arranged in panels, star, circles or any design which might be desired for decorative purposes. For side lamps a fancy moulding can be obtained and stained to suit the woodwork of the room or store where it is being installed.

Moulding can be fastened to the fire-brick or cement ceiling by drilling a hole ½in. in diameter and 4in. deep. A wooden plug is then driven into the hole. Holes to suit the wood screws to be used are then bored through the centre of the moulding and the moulding screwed to the ceiling. The holes for the plugs should be drilled into the ceiling at an angle and not perpendicularly. This avoids any danger of the moulding falling should the wooden plugs shrink and loosen in the holes. Expansion screws may also be used.

Should an electrolier be used in connection with the moulding, a hanger, similar to the one shown in Fig. 1, can be used, substituting a wooden block 1½in. thick, and as large as desired, in place of the outlet box. These blocks should be bored so as to allow the wires to come through near the centre; care must be taken to keep a wall of wood between the wires. The blocks, when used with the hanger, are fastened to the ceiling by using a ½in. pipe nipple long enough to project 1in. below face of block. A ⅞in. hole is bored through the centre and a lock nut is used to hold the block against the ceiling, a washer being placed between the wood and lock nut. Should lamps close to the ceiling be desired, there are various makes of lamp receptacles which can be fastened to the moulding direct.

If a fixture cluster is to be used close to the ceiling, a cone-shaped hole can be made in the ceiling, the apex of the cone pointing downward. A toggle bolt is inserted and fastened by forcing plaster of paris or cement in the hole. A hole large enough for the toggle bolt is bored in the centre of a block of wood, as previously described, and the block placed against the ceiling, the toggle bolt protruding. The block is locked against the ceiling by screwing the nut on the toggle tight, a washer being placed between the wood and nut, shown in Fig. 4.

A crowfoot (Fig. 5) is fastened to the block with wood screws 1½in. long. The cluster is screwed into the crowfoot before the latter is placed in position.—*Elec. World.*

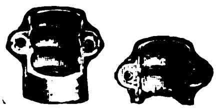


FIG. 2.

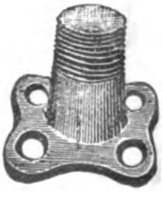


FIG. 3.

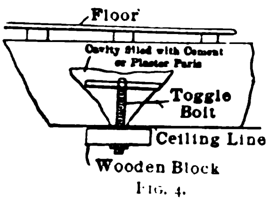


FIG. 4.

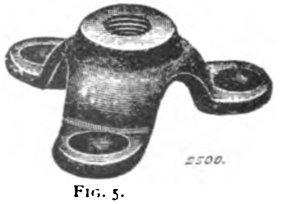


FIG. 5.

MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

Engineering Export Trade.

A FEW months ago there appeared under this title, in the *Journal of the Society of Arts*, an article written by Mr. W. Pollard Digby, which contains much that will be found of interest and value to those electrical manufacturers supplying plant for abroad. The author deals in the first place with comparative statistics of engineering export in the international sense, and in certain lines of specific engineering products. He supplements these figures and general remarks on the volume of trade with some valuable hints as to the actual handling of foreign orders.

The following abstracts from a somewhat lengthy article will doubtless serve as a guide to the many of our manufacturers who have not had much experience in export business but who are so far progressive as to make the development of this most important phase of business a leading feature of their policy.

Among the many items to which attention should be directed in regard to export trade, the packing of machinery and instruments for export is of supreme importance and merits careful attention. The trader must study the climatic conditions of the countries to which his manufactures are transported, the conditions of transport, and the facilities for handling his goods, both at the port of landing and up country. It would naturally be extremely prejudicial to electrical machinery, say, if, sent in too heavy a package to a port on the African coast, it became subject to all the disabilities of heavy packages removed from cranes and railways, *i.e.*, much levering over, any side up, with as much care and consideration as the ordinary labourer displays towards a package which he considers has been especially sent to strain his sinews, and therefore deserving of some hallmark of his resentment; in some cases even local repacking in smaller boxes becomes necessary for transportation up country, under awkward conditions as to obtaining suitable boxes, packing, and protecting material. Another class of mishap at this end of the transit is the breaking through of the wheels of the vehicle carrying heavy machinery into an insufficiently protected sewer, and it is therefore imperative that the weights of packages should coincide with the buyer's requests. Probably a strong heavy package will be best, but in cases where the machinery must be taken over rough roads and light bridges, necessarily it must be split up into a variety of packages even at the risk of their not all arriving simultaneously. It will be found conducive to satisfaction on the part of the buyer if such things are studied as enclosing spares of the less expensive small parts, such as bolts and nuts, keys, cottars, and other fittings, the losing or breaking of which is not particularly likely, but would, in the case of an oil engine up country, very possibly mean a cessation of running till such time as a new part can be contrived. The co-operation of the buyer who has become intimately acquainted with the effects of climatic and other drawbacks is, of course, very desirable. The exporter must endeavour to see the matter from the buyer's point of view, and the buyer to indicate to him in what way local circumstances differ from the normal.

In the wet season of a tropical climate rust especially is to be guarded against. Plating or platinising of small delicate parts of instruments, judicious greasing, the use of sealed water-tight cases are recognised means of combating this form of deterioration. Ebonite and rubber are also very susceptible to moisture. These may be protected by grease; insulations on dynamo coils, &c., are best protected by shellac varnish. The time of year at which the purchase will be despatched is worth noting; a shrewd observer has noticed that cases despatched from this country in the winter are liable to be filled with damp straw. In the case of a country which has from eight to ten months of non-summer conditions per annum this is a serious consideration.

It should not be very difficult to design a special class of machinery suited to the conditions met with in climates presenting extremes of heat and moisture, and this consideration brings us to a very important feature in the export of machinery, *i.e.*, the necessity for standardising not only each type and set, but every separate part, so that a cabled code-word will be all that is necessary to ensure the dispatch of exactly the right size of field coil, or piston rod, or whatever happens to have succumbed. The gradual elimination of awkward projections, or castings calculated to set up strains in cooling, and thus liable to break under slight concussion, has now been going on for some time in the leading ironworks of this country, and it should be possible for them each to arrive at their own especial set of sections, not in a spirit of desire merely to differ from competing firms, but in honest endeavour to improve on their design. In the more delicate electrical instruments necessary in high-tension station work, the packing question is especially important. The price of these is necessarily high, owing to the extreme care necessary to ensure accuracy, and the consequent employment of highly-skilled workmen. That the result of so much careful regulation should be exposed to all the vibration, if nothing worse, of a long journey with no further protection than a perfunctory padding up of the moving parts is not sound business. As at present designed, it would seem that the only way to deal with these is to remove the more delicate parts separately. Even in this country much expense is incurred by the insecure packing of such articles. In the case of measuring and testing instruments, many of them of special design, it is not easy to see how a special pattern, less susceptible to shocks, temperature, &c., could be produced for exportation, but with heavy machinery a little study of the conditions should enable the manufacturer to produce an article especially suited to the conditions under which it will have to work. Every consideration points to complete and comprehensive standardization as the most practical method of overcoming the disabilities of producing in one country articles especially suitable for use in a totally different one.

From this point the author takes up the defence of standardization in manufacture, commenting very favourably on the excellent work done by the Engineering Standards Committee, and lamenting the hindering practice of certain consulting engineers who still persist in specifying abnormal conditions and points of design all tending to waste of money and great interference with general industrial progress.

There is no reason why standardization should destroy that competition which is one of the recognised incentives to high-class production. The result of its universal adoption would be to cheapen production to an enormous extent, and consequently leave the manufacturer more chance of excelling by the quality and finish of his work, rather than by a claimed higher output or longer life difficult to justify in the face of constant changes in the machinery of production, and in the continued evolution of improved types. The advantage to the buyer has been pretty generally acknowledged unofficially by his tendency to adhere to certain makes for certain purposes, as produced by well-known houses, *e.g.*, boilers, steam engines, pumps, tramway motors, trucks, and controllers. The manufacturer is quick to appreciate the advantages of standardized co-operation and limiting of types, as witness the Cement Manufacturers' Association and the Cable Makers' Association among others. It remains for the consulting engineer to appreciate the safeguard afforded by specifying a product which has been tested in a variety of ways, supposing, of course, the absolute uniformity of one article with the rest.

After this, and in conclusion, Mr. Digby touches upon the vexed question of odious comparisons between ourselves and other countries as competitors in foreign markets. While acknowledging that this country is indeed backward in this direction, he raises a strong and reasonable protest against the reprehensible practice of publishing abroad our own shortcomings and the belauding of our competitors.

The great mass of the nation do not take into consideration that the English newspaper is read all over the globe, and where only two or three different newspapers penetrate, the words of the one which speaks with the most emphasis and conviction carry with them considerable weight. We are still liable to this complaint, which induces certain people, and through them certain newspapers, to cultivate the theory that, because their interest in the country or its trade is small, that country and its trade and everything else belonging to it are the objects of derision and perpetual targets for the shafts of sarcasm or abuse. This is not business, neither is it philanthropy, nor statesmanship, nor even truth. We have had far too much in the non-technical press of jeremiads concerning our lost supremacy, and unfounded decrying of what our manufacturers can and do habitually perform. In the name of fair play, this gratuitous advertisement of our rivals, and belittling of our fellow-countrymen, should cease.

The Engineering and Machinery Exhibition, London, 1907.

THE success of the Engineering and Machinery Exhibition held at Olympia in the autumn of last year has prompted a repetition for this year, which bids fair to be larger and even more successful in every way.

It will be recollected that the one complaint regarding last year's show was that it was hardly representative, and certainly not true to its very broad title. As an exhibition of modern machine tool practice it was above reproach, but many phases of engineering and machinery, particularly those dealing with the heavier classes of units, were conspicuously absent. It was very certain that the exhibiting firms had every reason to be thankful for the very tangible returns in the shape of orders.

It is intended that this year the exhibition shall remain open from September 19th to October 19th. The President is Sir Alex. B. W. Kennedy, LL.D., F.R.S.; the list of patrons includes the most celebrated gentlemen of the diplomatic, scientific, and commercial professions. The Advisory Council consists of the leaders of engineering manufacture, and is thoroughly representative.

It is proposed that the exhibition be divided into distinct sections, and from the following list of these sections it will be seen what immense benefit will be conferred upon all branches of engineering industry.

Mining Machinery and Appliances
Metallurgical Processes, Fuels, and Raw Materials.
Casting.
Forging, Pressing, Rolling, Stamping.
Machine Tools, Workshop Tools and Appliances.
Gas, Steam and Oil Engines (prime movers).
Transmission (power).
Lifting Appliances and Construction Plant.
Hydraulic Work.
Pneumatic Work.
Grinding, Crushing, and Ore Dressing Machinery.
Railway and Tramway Work.
Bridge, Roof, and Girder Work.
Naval and Marine Engineering Dockyard Plant.
Weighing and Measuring Machinery.
Road Locomotion.
Models.
Ropes (Wire, Hemp, &c.).
Inventions.
Electrical Appliances, Power and Light, Telegraph and Telephone.
Textile Machinery.
Agricultural Machinery.
Printing Machinery.
Chemical Plant.
Machinery for Treatment of Raw Produce.
Irrigation Machinery.
Sanitary, Building, and Estate Engineering Appliances.
Laundry Machinery.
Engineers' Stores, Paints, Compos, &c.
Military Engineering.
Waterworks Engineering.
Wood-working Machinery.
Machine Stoking and Labour-saving Appliances.

The educational aspect of the exhibition, which was one of the most satisfactory features of the previous undertaking, will again receive great attention, and facilities will be afforded to students to visit the exhibition under the guidance of thoroughly experienced gentlemen who will explain the various points of interest.

Arrangements will also be made for workmen and employees connected with important engineering workshops to visit the exhibition at specially reduced rates.

The important Colonial Conference which takes place this year is sure to attract a large number of colonial visitors more or less associated with engineering, many of whom will remain in England until after the opening of the exhibition, and in this connection special steps are being taken to have on show all the latest improvements in connection with gold mining, quartz crushing, and other mining appliances. Special facilities will be afforded to colonial exhibitors.

A series of lectures will again be given during the exhibition by distinguished authorities; this also was an important and highly successful feature on the previous occasion.

It will thus be seen that no pains are being spared to make the undertaking of real national benefit. It seems a far cry to the opening day, but there is a lot to be done in the organisation of this great enterprise. Messrs. G. D. Smith and F. W. Bridges were the managers of last year's exhibition. They have this in hand, and under their provedly capable control success is assured.

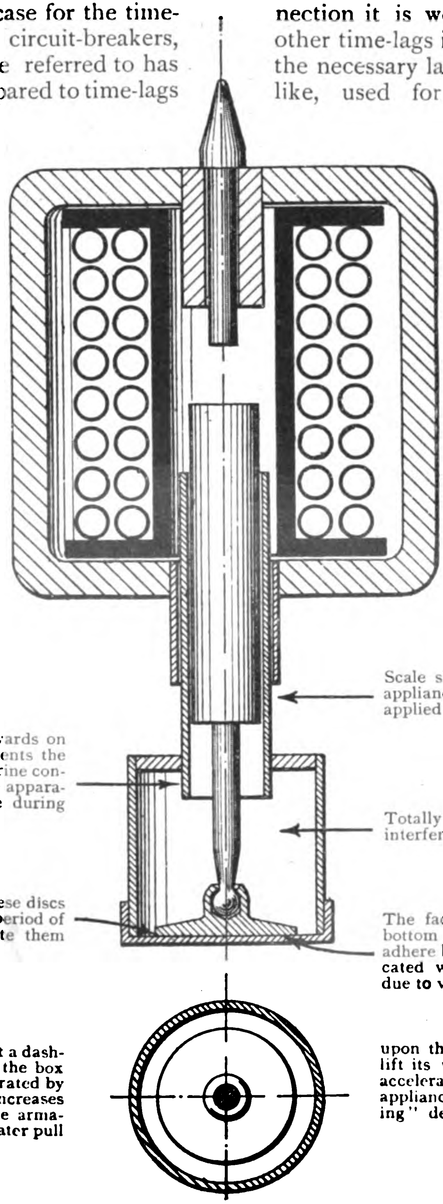
"Time Lag" Safety Device.

The Switchgear Company, Ltd., Birmingham.

THE Switchgear Company, of Birmingham, are issuing a pamphlet setting forth the advantages of the use of the Statter patent time lag in connection with circuit-breakers and motor-starters. The pamphlet makes out a good case for the time-lag principle applied to circuit-breakers, and the particular device referred to has many advantages as compared to time-lags which give a definite number of seconds of lag irrespective of the extent of the overload. The amount of lag given by the device described in the pamphlet is dependent upon the extent of the overload. This is illustrated by the following figures taken from a curve of a particular time-lag applied to a motor starter. With an overload of 10 per cent. a delay of six minutes was obtained before the circuit was opened; with a 20 per cent. overload the lag before opening is reduced to one minute; with 30 per cent., to half a minute; with 40 per cent., twenty seconds; with 60 per cent., ten seconds; and with 100 per cent., five seconds.

Although the pamphlet only deals with the application of the time-lag to direct-current apparatus, the instrument is equally applicable to alternating currents; in this connection it is well known that there are other time-lags in successful use in giving the necessary lag to oil switches and the like, used for controlling alternating-current circuits.

The Statter patent time-lag gives a curve of lag similar to those of the best of other types of instruments, but is claimed to have the following unique advantages: In the first place it is less expensive to produce, and in the second place it gives a hammer blow on the contacts at the time of acting, and enables the makers to short-circuit the contacts by means of a brush, avoiding the



Scale showing the amperes at which the appliance will ultimately break circuit if applied for a sufficiently long period of time.

The supporting tube projects onwards on the ink bottle principle and prevents the escape of the few drops of glycerine contained in the sucker box, when the apparatus is inverted or laid on its side during transit, &c.

Totally enclosed case, preventing dust interfering with the action of the suckers.

The mildest pull will separate these discs if applied for a sufficiently long period of time. A heavy pull will separate them instantly.

The face of the sucker and that of the bottom of the box are plane surfaces, and adhere by surface tension. They are lubricated with glycerine, which adds a pull due to viscosity.

Plan showing that the sucker is not a dash-pot, but is quite free to move in the box after the surfaces have been separated by $\frac{1}{1000}$th of an inch. This feature increases the hammer blow delivered by the armature, because there must be a greater pull upon the armature than that required to lift its weight, and therefore a greater accelerating force at starting. The appliance is essentially a "start-delaying" device as opposed to a device that checks movement.

FIG. 1. DIAGRAM SHOWING THE TIME-LAG AS APPLIED TO CIRCUIT-BREAKER MAGNET.

use of mercury cups which are necessary in the time-lags having a very small motive force.

The apparatus made by the Switchgear Company for alternating work is enclosed in a neat cast-iron case with glass front, and finished in nickel and black suitable for fixing on a switchboard.

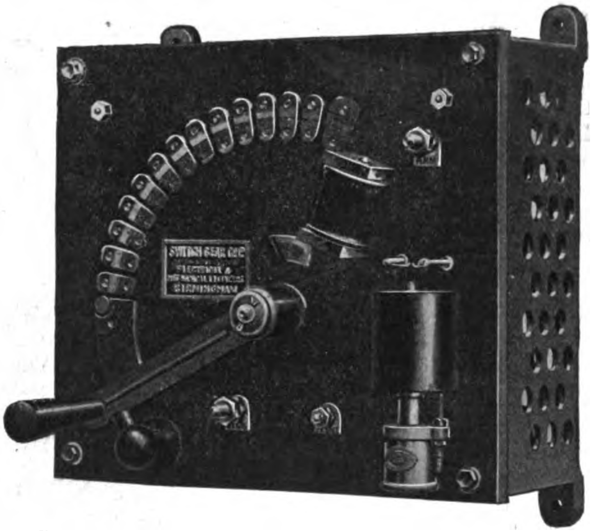


FIG. 3. TIME-LAG ATTACHMENT FITTED TO MOTOR STARTER.

The pamphlet under review shows an illustration of a circuit-breaker for heavy direct-current service, fitted with the time-lag attachment, and which we reproduce in Fig. 2. The time-lag is contained in the small metal box shown underneath the exciting coil of the circuit-breaker, and the adjustment to the latter for given currents is obtained in the usual way by screwing the box upwards or downwards, which has the effect of raising the armature nearer to or farther from the fixed magnet. The current at which the breaker will eventually open the circuit is shown on the scale which appears in the illustration. A circuit-breaker so equipped will not open on a 10 per cent. overload until a period of about six minutes has elapsed in the case of the standard appliance as manufactured by the Switchgear Company, but this time may be varied to suit the requirements of the particular case to which the circuit-breaker is applied. Fig. 3 shows the same time-lag appliance as applied to an ordinary motor starter.

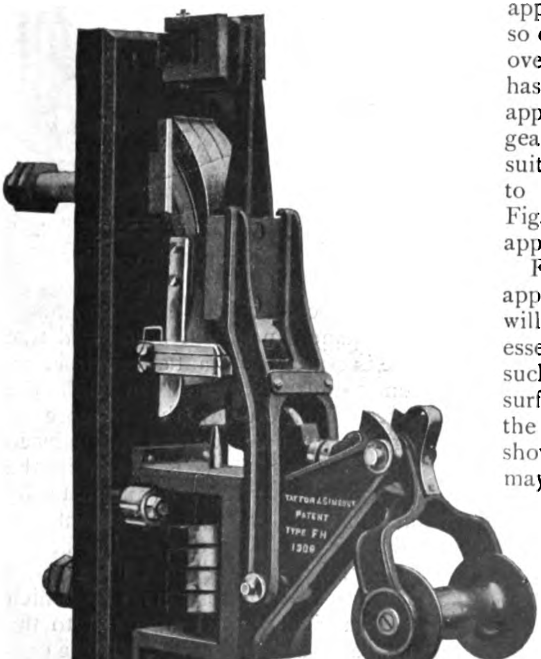


FIG. 2. CIRCUIT-BREAKER.
Made by the Switchgear Company, of Birmingham, for Motor of 50h.p. or upwards, with Time-Lag attachment.

Fig. 1 illustrates the principle of the apparatus, and is merely diagrammatic. It will be seen from this illustration that the essential part of the appliance is a metal sucker which adheres to a true surface by surface tension. The sucker is attached to the armature, which in the illustration is shown as a plunger of circular form, but it may be any form of movable armature. The disc to which the sucker adheres is fixed, and the lag is obtained by the time required to separate the two discs. The surfaces are merely lubricated with a suitable medium, and the mildest pull will operate them if applied for a sufficiently long period of time. The time required to separate them has already been referred to, and is the time of lag. It is to be noted that if the discs are separated by the smallest fraction of an inch, all retardation ceases, and therefore that the apparatus is essentially a "start-delaying" appliance, as opposed to an appliance which opposes motion after this has commenced.

In apparatus of this kind this point cannot be too much insisted upon—the position of the core of the electro-magnet determines the current at which the instrument will act. If, therefore, the time-lag is of a type which allows movement in an upward direction (referring to the illustration) to occur, it is obvious that even if the overload goes off the core may still continue to move upwards and open the circuit. In addition to this advantage, the Statter patent time-lag causes the armature to deliver a better hammer blow upon the catch, because there must be a greater pull upon the armature than that required to lift its weight, and therefore a greater accelerating force at the time that the core commences to shoot upwards.

The pamphlet points out that a motor for a given load may be smaller if protected with the time-lag than if protected by fuses or ordinary overload devices, and in consequence economy may be effected in the capital cost of motors where the time-lag is used. There is also a saving to be obtained in working on account of the increased efficiency of such a motor. Statistics are given, and the direction shown in which economy may be sought by the use of this appliance. The pamphlet should be read by all electric power users, and may be obtained from the Switchgear Company, Ltd., at a price of 3d. per copy.

A Large Three-phase Automatic Damper Regulator and a Large Lift Controller.

The Adams Manufacturing Company, Ltd.

THE attached illustration Fig. 1 shows a 35h.p. 550-volts three-phase damper regulator recently supplied by the Adams Manufacturing Company, Ltd., of London and Bedford.

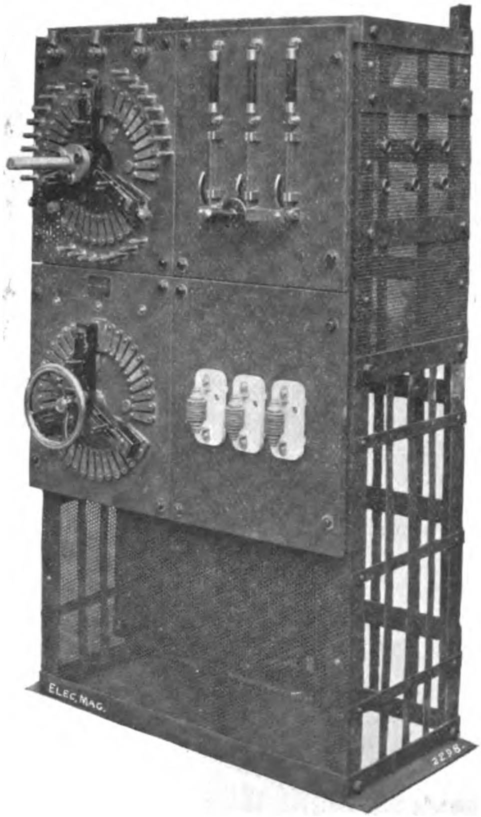


FIG. 1. THREE-PHASE AUTOMATIC DAMPER REGULATOR.

A three-phase induction motor of the slip-ring type is employed driving an induced draft fan supplied by the Sturtevant Engineering Company, Ltd. The boilers are arranged to operate a Mason damper regulator, which in turn actuates the three-phase rotor regulator shown on the left-hand top corner of the panel, while a separate hand-operated switch is provided for starting and stopping purposes. Mounted on the same panel are a triple-pole main switch with enclosed fuses and also three lightning arresters. The regulating and starting resistances are located in an angle iron frame behind the panel, and it will be noticed that the whole is of very substantial construction. The controller, in conjunction with the damper regulator, serves the purpose of speeding up the motor driving the induced draft fan whenever there is a fall in the boiler pressure, thus tending automatically to maintain the boiler pressure constant.

All danger of destructive arcing at the regulating switch is eliminated by a series of cylindrical carbon contacts with which another cylindrical contact attached to the regulating lever makes contact. These contacts are so placed that they always make and break circuit at the carbon contact and not at the working contact.

This is a system of boiler pressure regulation which should commend itself to consulting and station engineers in places where alternating current supply is available.

Fig. 2 shows a large 35h.p. lift controller as made by the Adams Manufacturing Company, Ltd., at their Bedford Works and recently installed at the Hartford Works, Oldham.

The lift is operated by a neat compact switch in the car, which uses the least number of control wires. For stopping the lift at the two limits of travel under any circumstances a limit switch is provided which is actuated by the movement of the car.

The controller proper comprises a suitable self-starter, main line switch, reverse switch, magnetic brake solenoid, and relays. The self-starter is of the multiple solenoid type, which consists of a number of contactors for controlling the different steps of starting resistance, in turn controlled by a master self-starter which provides very smooth and even acceleration under all loads.

For absolute safety and reliability the controller is made "double pole," in that both sides of the line are disconnected from the motor in the "off" position of the controller. Both sides of the self-starter solenoid coil are disconnected from the lines, ensuring quick return of the self-starter to the starting position.

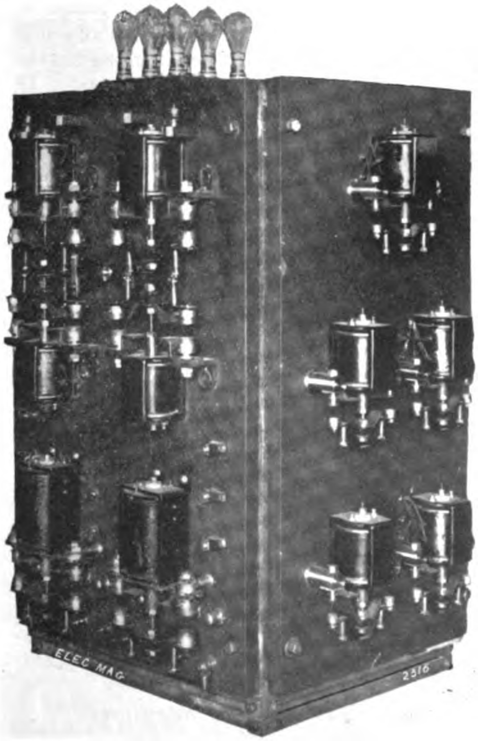


Fig. 2 Large Lift Controller.

The controller is arranged to control a suitable solenoid for releasing the mechanical brake, and provision is made for disconnecting both sides of the line from the winding of the brake solenoid. This ensures the quick and positive application of the brake in the "off" position of the controller, and prevents its action being interfered with by any inductive effects from other portions of the installation.

To provide for positive control of the lift from the car, the system of control has been so designed that all the wires leading from the switch in the car to the limit switch and controller proper are of the same polarity, so that there is no tendency for leakage currents or short circuits in the control cable.

The controller includes an automatic no-voltage device and time-limit overload preventer. All main-circuit breaking points are re-inforced by carbon contacts and powerful magnetic blow-outs.

The main line switch and reversing switch are interlocked to cause proper co-operation of these parts, and they are in addition interlocked with the self-starter so that it is impossible to close the circuit to start the motor until all of the starting resistance is in circuit.

This particular controller is designed to ensure constant speed in the running of the lift, and only one speed is available. Very often, however, two speeds are desirable, especially in a quick running lift, as the operator is then enabled to slow the car down very quickly under all conditions of load, which materially assists him in making quick and accurate stops. Controllers of the type illustrated can be provided with two or more speeds if necessary, and this speed control is obtained entirely by shunt field resistance under the control of the operator in the car, so that he can not only use the lower speeds to assist him in stopping, but can also run continuously at any one of the available speeds whenever he desires.

Motorcar Specialities.

Gratze Patents and Engineering Syndicate, Ltd.

THIS firm is well known as manufacturers of electrical and general accessories for mechanically propelled vehicles. Their specialities in this direction include revolulution counters, speed indicators, accumulators, and many other details of motorcar and tramcar equipments.

The illustrations herewith show two of the most recent introductions of the Gratze Syndicate. The electric horn (Fig. 1) is operated from a small battery circuit and works on the principle of a make and break electro-magnet vibrating a springy and resilient diaphragm, the diaphragm itself acting as the current interrupter, in the usual method through platinum points. This is a distinct novelty, protected by patents, and is meeting with considerable demand.

With regard to the pressure gauge (Fig. 2), this is simply an ordinary pressure gauge to about 120lb. to the square inch, its main object being to enable motorists and the users of pneumatic tyres to continually test the pressure in the tyres at any instant and so maintain this at a uniform figure; it saves the laborious trouble of continually screwing the valve of the pump on to the tyre valve each time a test is desired. The gauge is simply screwed over the valve, and on pressure of the spring button it immediately indicates the exact pressure in the tyre. If the pressure should not be to the required figure, the pump can then be attached to the same gauge without the trouble of removing it from the tyre.

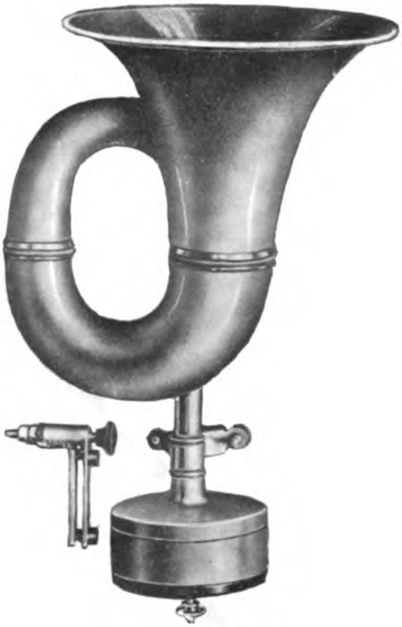


FIG. 1. AN ELECTRIC HORN.

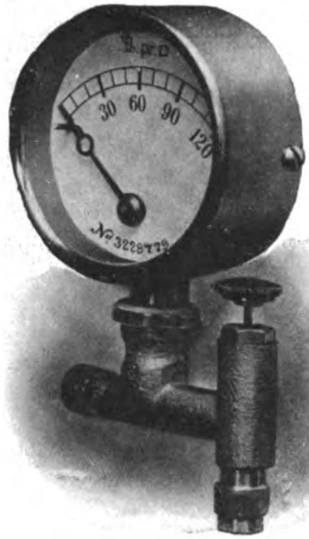


FIG. 2. PNEUMATIC TYRE PRESSURE GAUGE.

◆

Power Installations. — JOHNSON AND PHILLIPS, LTD., have recently received orders from the South-West Cornwall Mines, Ltd., for the supply and erection of gas plant, engines, dynamos, switchboard, electrical pumps and plant; and from the Lamson Paragon Supply Company, Ltd., for the supply and erection of all electrical plant for this company's factory, including dynamos, motors, and switchboards.

ELECTRICAL MANUFACTURING FIRMS who make a speciality of COLLIERY WORK are invited to communicate at once with the Editor of The ELECTRICAL MAGAZINE, who will be able, through the instrumentality of this Journal, to put them in Direct Touch with the most UP-TO-DATE COLLIERY MANAGERS who are adopting or thinking of adopting Electrical Applications.

LITERARY Section.

Including

Reviews of Books, List of Practical Works, Publishers' Notices, Standard Publications, WORLD'S ELECTRICAL LITERATURE, New Catalogues, &c.

Readers will find this Section invaluable. We shall be pleased to furnish further particulars regarding the Books dealt with herein, or to supply information concerning any other books. Communications requiring an answer through the post must be addressed to Literary Editor, ELECTRICAL PUBLISHING CO., LTD., 4, *Southampton Row, London, and accompanied by stamped envelope.*

ELECTRIC TRACTION.

Electric Railway Engineering. BY H. F. PARSHALL, M.INST.C.E., AND H. M. HOBART, M.I.E.E. (LONDON: ARCHIBALD CONSTABLE & CO., LTD. PRICE 42S. NET.)

This is an important addition to the electrical engineer's library; dealing in a very thorough manner with electric power practice in railway as distinct from tramway operation, it will doubtless be accepted as the manual for heavy electric traction work.

In the Preface the authors broach the great question of the moment—the standardization of electric railway practice—and enter the direct-current *versus* alternating-current controversy, stating "while in our judgment it is impossible at the present time to predict where the limitations (of the d.c. motor and the a.c. motor) will be reached, we are satisfied that a careful comparison of the two at the present time is decidedly to the advantage of the high-tension continuous-current motor."

The book is a large one, indeed many would have preferred that it had been divided into three or four volumes; there are upwards of four hundred illustrations, one hundred and twenty tables, and nearly five hundred pages of text. The scheme of the book consists of a subdivision into three parts: the mechanics of electric traction; the generation and transmission of the electrical energy; the rolling stock. Throughout the work particular attention has been given to the graphical representation of results and data and to the inclusion of tables—all of which make for easy and ready reference as well as for concise treatment and real value of matter.

Essentially practical and complete, dealing with accomplished facts rather than with theoretical surmises, Messrs. Parshall and Hobart have added very greatly to their already established respective reputations in engineering authorship, and have in this their latest success produced a book which will come as a boon to the railway engineer seeking after truth and knowledge of electricity's possibilities as a railway power.

Elements of Electric Traction. FOR MOTORMEN AND OTHERS. BY L. W. GANT. (LONDON: HARPER & BROS., 45, ALBEMARLE STREET, W. PRICE 5S. NET.)

Being lecturer to a class of motormen the author has compiled this work as dictated by necessity. It is intended to serve as a text-book for the artisan and beginner who aspires to a practical knowledge of the why and wherefore of electric traction matters. The book is more than its title would indicate; it is in reality a well-written text-book introductory to the study of electrical engineering in any phase. It is in this that its great value rests, the principles of generation and transmission of current, of the action of dynamos, motors, and controllers are followed through in a simple and easily understood style, step by step towards practice and problems of modern electric traction. Nor is the subject dealt with in a superficial manner; the work is thoroughly up to date and is replete with many numerical examples and useful line drawings and diagrams. No student of electrical engineering or junior in the tramway department should hesitate in procuring Mr. Gant's book, which is unique in its contents and has the further advantage that it is cheap and remarkably good value.

TECHNICAL EDUCATION.

Bread-and-Butter Studies AND THEIR RELATION TO THE HIGHER EDUCATION OF WORKMEN. AN ADDRESS TO TECHNICAL STUDENTS BY WILLIAM RIPPER, M.INST.C.E. (LONDON: LONGMANS, GREEN & CO., 39, PATERNOSTER ROW. PRICE 6d. NET.)

In this address, given at the Annual Meeting of the Technical Schools, Wolverhampton, in October last, the author discusses the connection between technical school training and the higher education of working men. "Higher education" is defined as that which lifts a man up out of his narrow groove of life and thought, enabling him to give fuller expression to the power and capacity that are in him—this and more, viz., the development of the human side of character. For this last reason the writer would prefer that what is generally known as "higher education" should be described as "broader education." "Bread-and-Butter Studies" is the term applied generally to those studies having a direct bearing upon the student's particular trade or profession, and are therefore those essential in these strenuous days. Professor Ripper indicates how these last studies at the technical schools work towards the same ends as his broader education. It is not a long address—the pamphlet has only about a dozen pages, but it is of interest, and in a nutshell strongly advocates the cause of technical education. The author commends the growing practice of lengthening the period of school life—"One day's study per week is worth as much as a whole week's evening study." Parents, students, and employers are ever coming into line with the requirements of modern international competition, and the "Bread-and-Butter Studies" of the technical schools play a great part in the march of progress.

ELECTRICAL HUMOUR.

The Electrical Engineer's Ballad Book.—A COLLECTION OF MISCELLANEOUS VERSES REPRINTED FROM "THE ELECTRICAL ENGINEER" AND OTHER SOURCES. ILLUSTRATED. (LONDON: BIGGS & SONS, 139-140, SALISBURY COURT, FLEET STREET, E.C. PRICE 1s.)

Whatever else may be said of this book, it is certainly a novelty, and, we believe, stands alone as an electrical volume of intentional humour. Pictures and rhyme relate many amusing episodes and events of the electrical man's work in all phases—from the "Perjured Plumber" who essays to wire a mansion to the "Exhibition Slave," overworked with the business of entertainment at the electrical exhibition. There is, of course, little to review in a work of this class; we can only say that from cover to cover it is genuinely funny, and that no one will begrudge the modest shilling thus spent. Electrical engineering is a serious profession, and for that reason the glimpses of its lighter side as given in this ballad book are the more enjoyable and forceful.

POWER TRANSMISSION.

Electric Power Transmission. A PRACTICAL TREATISE FOR PRACTICAL MEN. BY LOUIS BELL, PH.D., M.AM.I.E.E. (LONDON: ARCHIBALD CONSTABLE & CO., LTD. PRICE 16s. NET.)

This work has grown to be quite a standard electrical text-book; it has reached the stage of a fourth edition in less than ten years, and has been revised and enlarged so as to bring its contents well up to date. To those who are not already familar with this work the best that can be said is that it is excellently written, is well arranged, and can always be recommended as a book of practical value. It is not in any case highly theoretical, but conveys its large amount of information in a style understood by the beginner and the general engineer.

In these days when the development of electricity is very greatly characterised by its ever-increasing ease and efficiency of transmission, it behoves every one interested in power production and use to keep in touch with the problems and practice of electrical transmission.

DIRECTORIES.

The Universal Electrical Directory (J. A. BERLY'S), 1907. CONTAINING A COMPLETE RECORD OF ALL THE INDUSTRIES DIRECTLY CONNECTED WITH ELECTRICITY AND MAGNETISM, AND THE NAMES AND ADDRESSES OF MANUFACTURERS IN GREAT BRITAIN, INDIA, THE COLONIES, AMERICA, THE CONTINENT, &C. (LONDON: H. ALABASTER, GATEHOUSE & CO., 4, LUDGATE HILL, E.C.)

This well-known standard book of reference is published in January of each year, and thoroughly revised locally as well as by circulars. It contains the names and addresses of the members of the electrical trades and allied industries all over the world. The 1907 edition consists of four sections: the British, with 14,430 names; Colonial and General, 4640 names; Continental, 7738 names; and the U.S.A., with 6075 names—a total of 32,883 names, and this after a careful elimination of unimportant entries. Each section is again sub-divided into an alphabetical and classified section, and in the case of the British, a geographical section has been added, which is of unquestioned use to travellers. A thumb index simplifies the turning up of any part desired.

The alphabetical sections include telegraphic addresses and telephone numbers and codes, and many financial particulars regarding British limited liability companies.

Lists of all electricity undertakings in the United Kingdom and Colonies are given, showing the nature of the supply, system of distribution, capacity of plant, voltage, and chief engineer's name, and in the case of alternating current the phase and periodicity also appear.

The prices of the Directory, post free in the United Kingdom, are 14s., Colonies 15s., United States of America 18s., and other countries 16s. The "A" edition, started a few years ago for the convenience of home and Colonial firms, contains the British and Colonial and General Sections only, prices post free in the United Kingdom 10s.. Colonies 11s., United States of America 14s., other countries 12s.

Sell's Telegraphic Addresses AND NATIONAL DIRECTORY OF LARGE COMMERCIAL HOUSES, 1907. (LONDON: HENRY SELL, 166, FLEET STREET, E.C. PRICE, INCLUDING THREE SUPPLEMENTS, ISSUED QUARTERLY, 21s.)

Telegrams have increased by nearly 1,000,000 during the year. Sell's Directory now contains foreign and colonial cable addresses (upwards of 20,000), the binding has been strengthened, and there are many improvements introduced, making the volume a complete directory of some 70,000 of the largest firms in the United Kingdom, arranged alphabetically, and also arranged under their trades. It is claimed that no such national list exists. There are 2200 well-printed pages of names of all the great concerns in the country for quick reference, and telegraphic addresses and telephone numbers, every particular being exact and up to date. Each three months subscribers are advised free as to any alterations, additions, &c.

The Directory is absolutely complete to the end of 1906, and contains every new telegraphic address or alteration registered at the Post Office up to December 31st.

A complete list of our Consuls in foreign countries will be found in the volume, classified under the towns in which they are resident. This is of great importance to firms doing an export trade. There are also special articles on the world's industries, post office information, and charges for cables the world over, arranged under the heads of countries. The article, "Hints and Suggestions to Telegraph Users," is most piactical, and will well repay perusal, as great savings can be effected by following the advice given.

To those doing even an ordinary amount of business this book must be most useful, but to large firms it is indispensable.

Wireless Telegraphy and the Conference. BY CHARLES BRIGHT. AN ARTICLE IN *The Monthly Review*, DECEMBER, 1906. (LONDON: JOHN MURRAY, ALBEMARLE STREET, W. PRICE 2s. 6d.)

This is an interesting article and should be read by all for the important reason that, as indicated by the author on several occasions in 1902 and 1903, and repeated here, wireless telegraphy is of national moment, necessitating Government control on an Imperial basis.

Mr. Bright opens with a terse criticism of the behaviour of the daily press in reference to the Marconi system and the recent Conference, indicating the nonsensicalness of the attitude taken up. For example, it is shown how absurd is the statement freely circulated to the effect that a check of any description to the Marconi system would mean the stoppage of all wireless telegraphy development. Surely it is *monopoly* that impedes progress.

After briefly touching upon the temerity of politicians in assuming positions as telegraph experts, and duly noting the way in which the public press seize upon opinions from this source to the exclusion of views by the trained and experienced expert, Mr. Bright passes on to the historical stage of his subject.

History repeats itself. As ten years ago there was controversy regarding the individual responsible for submarine telegraphy, so to-day there is doubt as to the individual we are indebted to for wireless telegraphy. In both cases it is plain to be seen that the result is the outcome of original research and discovery by a number of persons. If anyone could justly claim a monopoly of Hertzian wave telegraphy, Mr. Bright gives the palm to Sir Oliver Lodge; at the same time he agrees that Mr. Marconi has done more than any man towards developing the commercial possibilities of wireless telegraphy. In citing the history, the author is very clear in his facts, and the statements are presented in an interesting and lucid style entirely free from bias.

A very important feature of wireless telegraphy in general is introduced where the author mentions the well-known systems other than the Marconi system. Here is pointed out the immense advantages under which the Marconi system has been developed, how obviously unfair has been the treatment of other systems in comparison, and how desirable it is for the national welfare that there should be "a fair and square trial of all British systems under similar conditions—such a trial to precede the adoption of any single one even for a moderate period of time."

The Conference, its ostensible object, its real object, and the result, are all forcibly criticised in a strain not favourable, as will be gathered from the foregoing.

In concluding this brief notice of a courageous and outspoken view on a subject of vital national import, the reiteration of Mr. Bright's final paragraph will appeal with even more force than it did when written—for time is already beginning to tell:—

"Three days before the publication of this article an interesting and important demonstration of yet another system of 'wireless' telegraphy will have taken place at the Queen's

Hall, London. This new invention hails from Mr. Valdemar Poulsen, of Copenhagen. It may prove as superior by sea as the Lodge-Muirhead system has overland. In that case we shall have another definite illustration of the mistakes made in entering into long binding agreements, such as that of the Admiralty with the Marconi Company, in operation until 1914."

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Practical Coal-Mining. BY LEADING EXPERTS IN MINING AND ENGINEERING; UNDER THE EDITORSHIP OF W. S. BOULTON, B.SC., F.G.S. (SIX VOLUMES, PRICE 6s. NET EACH VOLUME.)

A new and important treatise on coal-mining is to be immediately published under the title "Practical Coal-Mining." The work is in the editorial care of Prof. W. S. Boulton, of University College, Cardiff, who has gathered together a staff of the first experts in the subject from the three kingdoms and elsewhere. Thus professors and lecturers on mining in Cardiff, London, Glasgow, Newcastle, Leeds, and Calcutta have important sections under their care, and further sections come from mining engineers and colliery managers in the various mining centres. The work will therefore be most authoritative and very representative. It will present not only all branches of a very wide subject in all its varied practical, theoretical, and economic aspects, but will describe the most up-to-date methods adopted in every mining district of this and other countries. In short, the complete series will form a comprehensive treatise on the whole subject of coal-mining.

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Coal-mining and electric-power application and generation are coming ever into closer touch with each other: a complete and modern treatise of this description will be found of great value to electrical engineers generally, as well as to those engineers and managers who are solely engaged in the getting of coal. Further particulars and prospectus of above forthcoming work can be obtained from The Electrical Publishing Company, Ltd., 4, Southampton Row, London, W.C.

New Catalogues.

Flexible Conduits. — THE ARMORDUCT MANUFACTURING COMPANY, LTD., send an artistic little book giving the results of independent tests made on Armorduct conduit in competition with other makes. The tests were made at the Westminster Electrical Testing Laboratory.

New Steel Works.—THE PARKER FOUNDRY COMPANY.—Leaflet announcing the fact that the company have acquired 5¼ acres of land alongside the Midland Railway at Little Chester, Derby, for new works. The list of works contractors is given, and also a note that the firm makes a speciality of small machine castings of the quality required by the Admiralty, railway, and other authorities: tensile strength 24 to 25 tons per square inch, with elongation ranging from 15 to 20 per cent.

New Catalogues and a Useful Binder.—UNION ELECTRIC COMPANY, LTD.—We have received a useful and elegant binder of the Stolzenberg type from this company, wherein their numerous circulars and price lists can be conveniently assembled. The lists sent us include those dealing with dynamos, arc lamps, switchgear, meters, and motors, all as manufactured by this well-known firm. The publications are of quite recent date, and will well repay study by the buyer of electrical plant.

Fuses.—A. REYROLLE & CO., LTD.—Illustrated pamphlet describing, with prices and in some cases dimensions, a special line of ironclad switches, high-tension fuses, instrument fuses, and also those of the quick-break switch and tubular types.

Tramway and Railway Trucks.—MOUNTAIN & GIBSON, LTD.—A convenient little folder containing a series of interesting illustrations of this firm's standard products in the way of tramway trucks, watering cars, track sweepers, &c. Also in the form of a pamphlet an illustrated reprint of a descriptive article which recently appeared in THE ELECTRICAL MAGAZINE, and which gives particulars of this progressive firm's standard designs of trucks for rolling stock and special steel cars.

Burnand Transformers.—W. E. BURNAND & CO., SHEFFIELD.—A circular letter advising the fact that this company has purchased the patterns and most of the plant of the Burnand Transformer Company, Ltd., Oxford Street, Salford, and that such transformers can now only be obtained from this company at Sheffield. It is also stated that their present works are taxed to their full capacity, but that the new works are rapidly approaching completion, and are expected to be fully working early this year.

Steam Traps.—GEIPEL & LANGE, the owners of the well-known Geipel steam trap, produce a circular giving illustrations and technical description of this device, in which they have also taken the opportunity of publishing a caution to those who may be led into the purchase or manufacture of infringements of their patents, extracts being given from the judgment in a recent law suit in which Messrs. Geipel & Lange were successful.

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Ornamental Fittings.—THE EDISON AND SWAN UNITED ELECTRIC LIGHT COMPANY, LTD.—This company send us illustrated leaflets showing types of electroliers which are certainly of exceptionally handsome and effective designs. A novelty is the "Ediswan" piano standard, which only requires to be known to ensure its ready adoption, since it is exactly what has been wanted for some time, fulfilling its purpose perfectly.

Cables and Wires, Radiators.—H. A. JACKSON & CO., SALFORD.—Price list of cables and wires ranging from single 18 up to 37/14s.w.g. The cables are of English manufacture, rubber insulated, 600 megohm grade. Price list of B.T.H. lamps. Price list of H.A.J. incandescent glow lamps fitted with non-hygroscopic vitrite caps. Also price list and illustrations of a special line of art metal luminous radiators.

Extending Fittings.—JOHN DUGDILL & CO., FAILSWORTH.—A large postcard having numerous illustrations of this firm's specialities in the way of patent movable fittings. A glance over these illustrations convinces one that there is no limit as to how and where the electric light may be placed. The fittings are of typical utility, and should be very popular for workshop lighting and wherever directed illumination is required.

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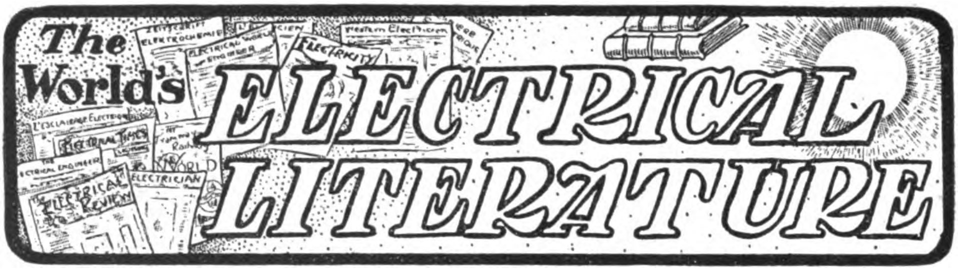

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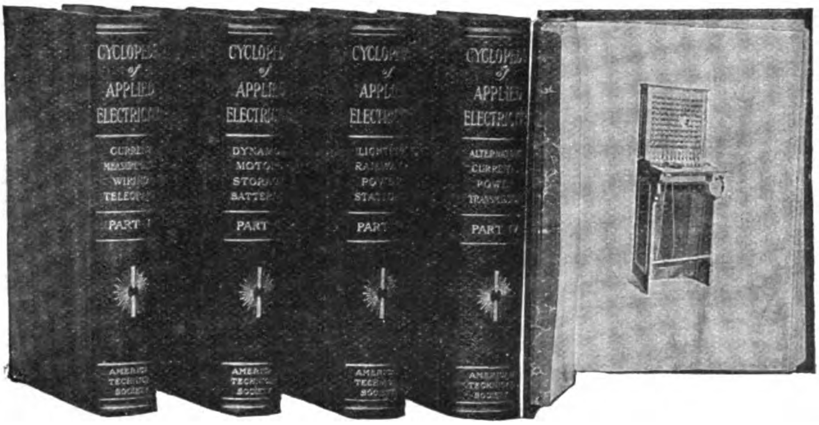

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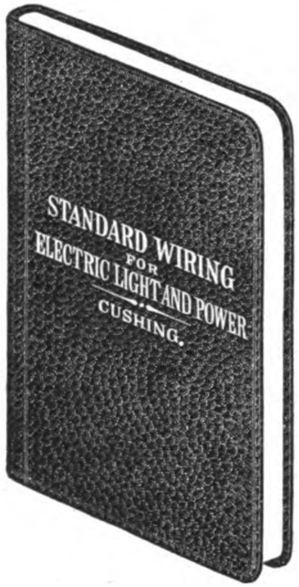

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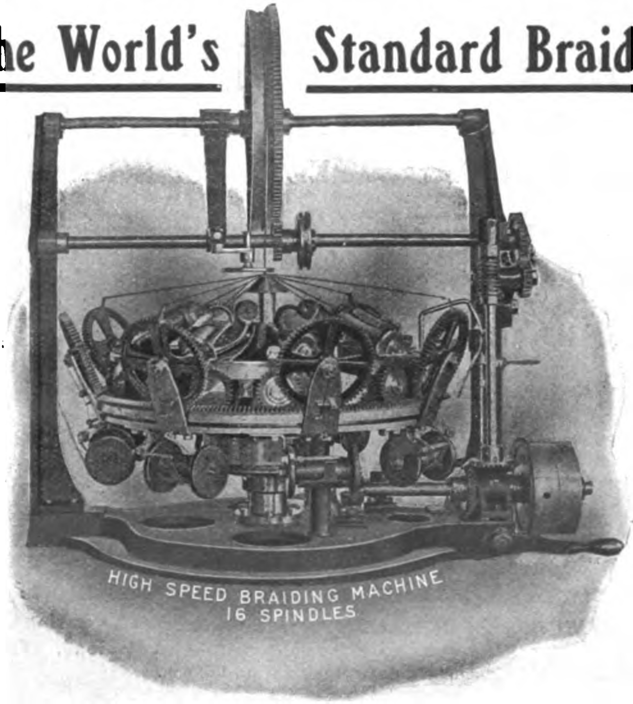

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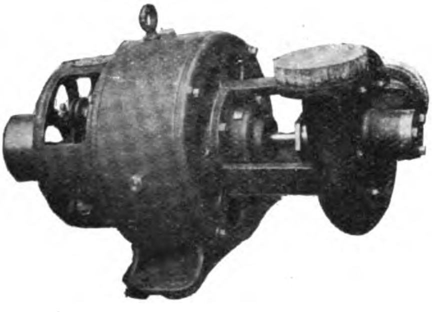

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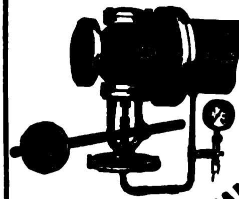

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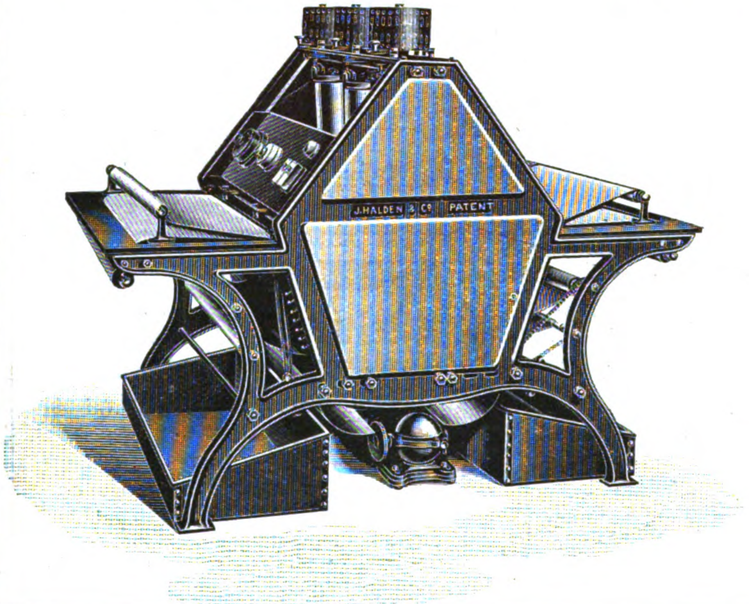

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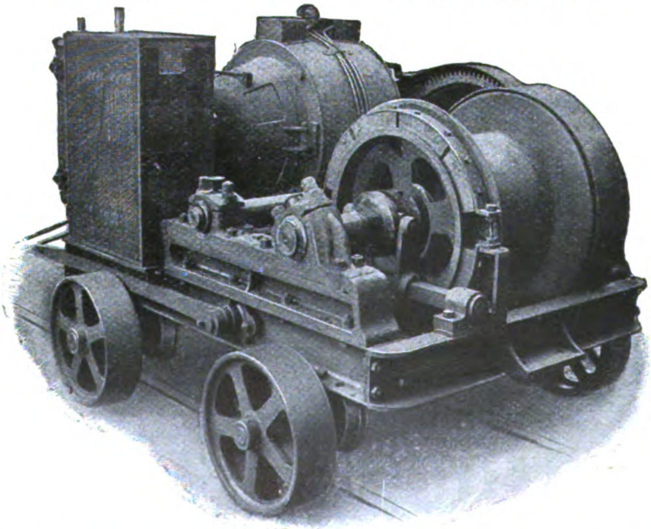

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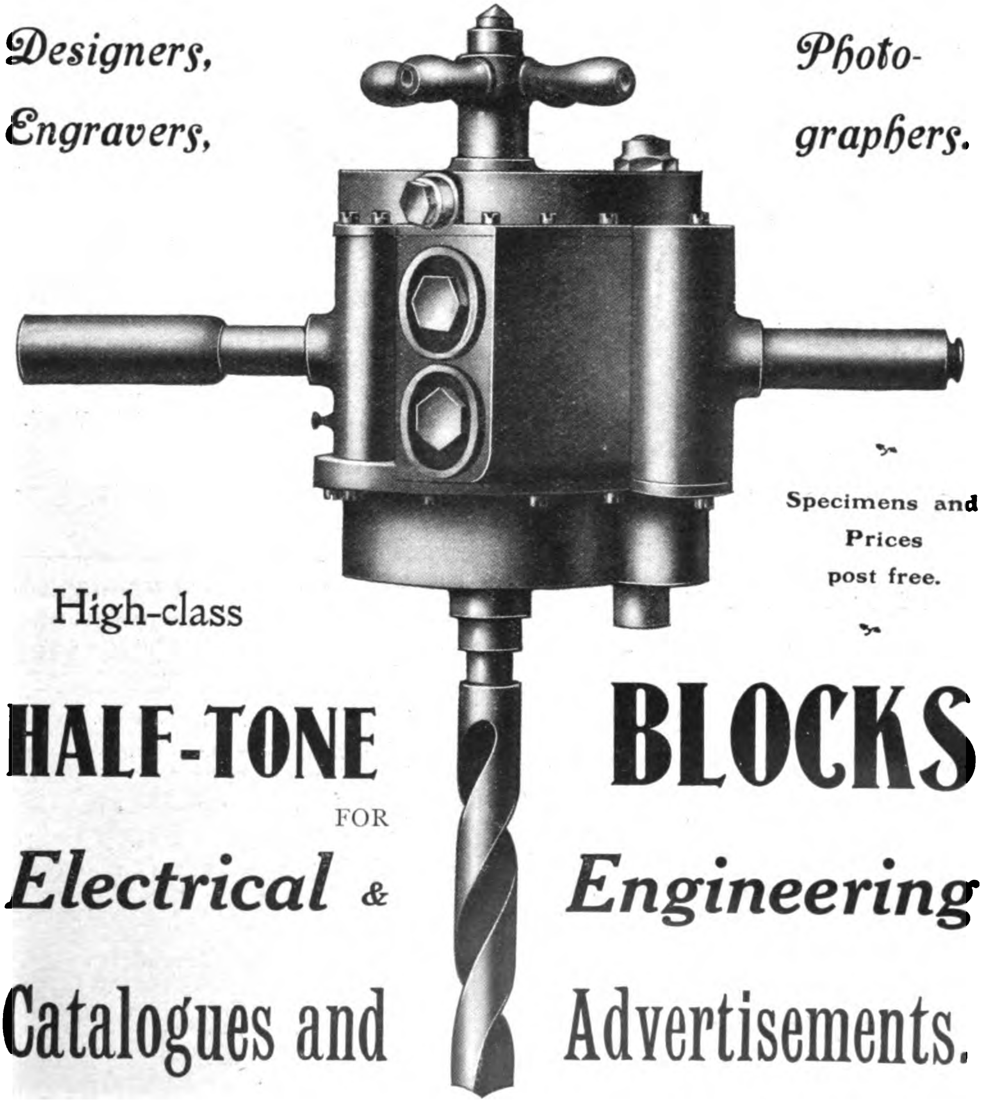

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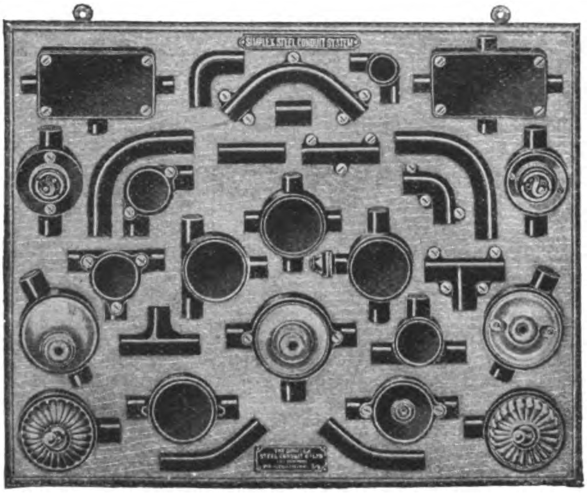

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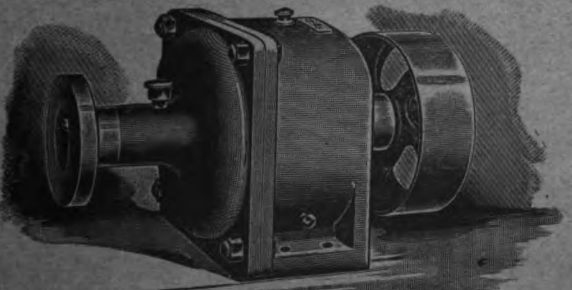

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Index to Advertisers.

For specialities and manufactures of firms below, see preceding Buyers' Guide.

PAGE
A. E. G. Electrical Co. of South Africa, Ltd. . 7
A. E. G. English Manufacturing Co., Ltd. . . 15
Adams Manufacturing Co., Ltd. . . . .
Angus, George, & Co., Ltd. 29
Armorduct Manufacturing Co., Ltd. . . . 40
Automatic Standard Screw Co. . . . ii. of cover
Babcock & Wilcox, Ltd. 6
Bennis, Ed., & Co., Ltd. . . . . . .
British Steam Specialties, Ltd. . . . .
British Westinghouse Electric & Mfg. Co., Ltd.
Broadbent, Thos., & Sons, Ltd. . . . .
Campbell Gas Engine Co., Ltd. . . .
Clarke, Chapman & Co., Ltd. . . . 6 and 23
Connolly Brothers, Ltd. 26
Corlett Electrical Engineering Co., Ltd. . . 33
Craven Bros., Ltd. . . . .
Crompton & Co., Ltd. 5
Crypto Electrical Co. . . . . . .
Cundall, Sons & Co., Ltd. . . . . . .
"Cyclopædia of Applied Electricity" . .
Davis, John, & Son (Derby), Ltd. . . . 30
Diamond Coal Cutter Co. 34
Diesel Engine Co., Ltd. 10
Electric & Ordnance Accessories Co., Ltd. .
Electrical Standardizing, Testing & Training Institution . . . .
Electromotors, Ltd. . . . .
Ferranti, Ltd. 17
General Electric Co., Ltd. 19
Glaholm & Robson, Ltd. 31
Goodman Manufacturing Co., Ltd. . . 36 and 37
Green, E., & Son, Ltd. 16
Halden, J., & Co. 28
Hall, B. J., & Co., Ltd. . . . . .
Hannan & Buchanan 31
Hardy Patent Pick Co., Ltd. 1

you should consult the Special List of Practical Books following page 248.

Index to Advertisers—*continued.*

PAGE
Hendry, James . . . . iii of cover
High Speed Braiding Machine Co., Ltd. . .
Holmes, J. H., & Co. 22
Hornsby, Richard, & Sons, Ltd. . . .
Howden, James, & Co. 13
Hurd, McKendrick & Co. 27
Hyatt Roller Bearing Co. . . . . . .
India-Rubber, Gutta-Percha, & Tel. Wks. Co., Ltd. 4
Industrial Engineering and Motor Co., Ltd. . 3
Lancaster & Tonge, Ltd. . . . . . .
London & County Printing Works 248d
Longmans, Green & Co. 248d
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"Modern Electric Practice" . . . . .
"Modern Engines and Power Generators" . .
"Modern Mining Practice" 248c
Mountain & Gibson, Ltd. 8
Nalder Bros. & Thompson, Ltd. 8
Neill, W., & Son, Ltd. 35
Newton Bros. 28
North-Western Electrical Appliance Co. . . 38
Pearn, Frank, & Co., Ltd. 32
Phillips, Charles D. 32
Phœnix Dynamo Manufacturing Co., Ltd. . .

PAGE
"Practical Coal-Mining" . . . . tinted suppt. v.
Press Etching Co. 39
Pritchetts & Gold, Ltd. . . . . . .
Reason Manufacturing Co., Ltd. 9
Rhodes Electrical Manufacturing Co., Ltd.. .
Ross, R. G., & Son . . . . . . iii. of cover
Santoni, D., & Co. (1906), Ltd.
Simmonds Bros., Ltd. 28
Simplex Conduits, Ltd. 18
Smith (A.) and Stevens. . . . . . .
"Standard Wiring" . . . . . tinted suppt. vi.
Stewarts & Lloyds, Ltd. 30
Stirk, John, & Sons . . . .
Stolzenberg Patent File Co. . . tinted suppt. vii.
Sun Electrical Co., Ltd. . . . . . .
Suter, Frank, & Co., Ltd. 14
Switchgear Co., Ltd. 11
Temperley Transporter Co. . . . . ii. of cover
Thames Ironworks, Shipbuilding and Engineering Co., Ltd. . . . . .
Thom, John G. 12
Turnbull, Alex., & Co., Ltd. 16
Union Electric Co., Ltd. 18
United States Metallic Packing Co., Ltd. . . 1
Waygood, R., & Co., Ltd. . . . . .
Wild, M. B., & Co., Ltd. 38
Winn, Charles, & Co.. . . . . . .
"The World of To-day" . . . . . .
"World's Work" . . . . . tinted suppt. vi.

LITERARY CONTENTS of this Issue of

The ELECTRICAL MAGAZINE.

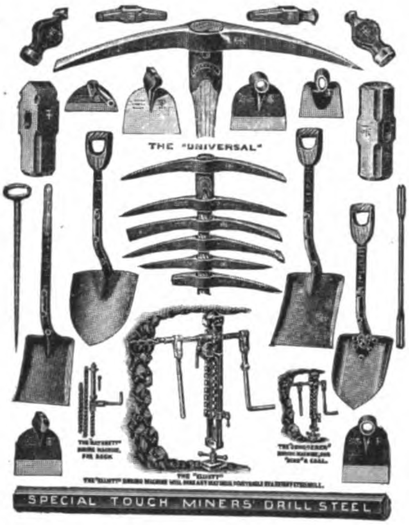
PAGES
The World's Electric Progress . . . 117-120
Colliery Number 117
The Evil of Trade Unions 117
A Progressive Industry 118
Colonial Postage Reform 118
Commercial Motor Vehicles 120

ELECTRIC POWER IN COLLIERIES.

Some General Points 121
The Electric Power Supply 122-138
Gas or Steam Units 122
Gas Power Plant 123
Steam Power Plant 125
Fuel Economy 126
Steam Economies 129
Water Treatment 132
Alternate Current or Direct Current . . 132
Electric Generating Plant. 134
Main Switchboards 136
Current Transmission and Distribution . 138-155
Selection of Cables 138
Armoured Flexible Cables 139
Wiring Work 141

PAGES
Underground Switch-gear 144
Leakage Indicators (A. F. Harris, A.M.I.E.E.) 150
Electrical Winding 155-169
Some New Flywheel Storage Systems (A. P. Wood) 156
Winding Economy and First Cost . . . 169
Electrical Haulage 170-179
Electric Locomotives 179-184
Electric Pumping 184-195
Electric Coal-cutters 196-215
Electric Coal Drills 215
Auxiliary Electric Power Appliances and Accessories 221-226
Some Typical Colliery Installations . 227
The Aberdare Collieries of the Powell Duffryn Co. (Charles P. Sparks) . . . 227
The Electric Power Equipment of the Tarbrax Oil Co., Ltd. (James Caldwell) . 239
Electric Power Installation at Bradford Colliery 240
The Mountain Ash Collieries of Nixon's Navigation Colliery Co. 246
Bwilfa Collieries 248
Practical Books Section 248a
List of Colliery Books 248d

You will find the List of Technical Books (with particulars and prices) given in this Issue invaluable to you.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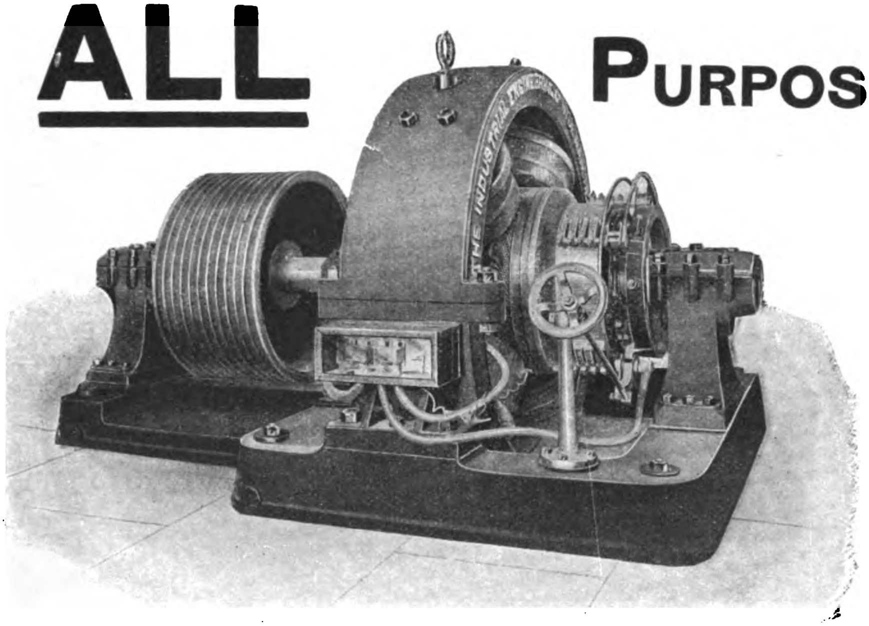

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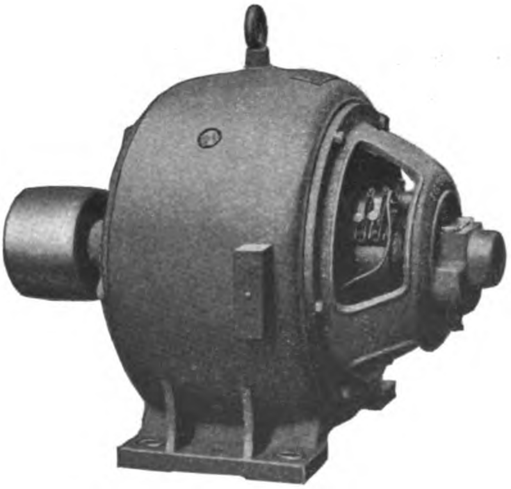

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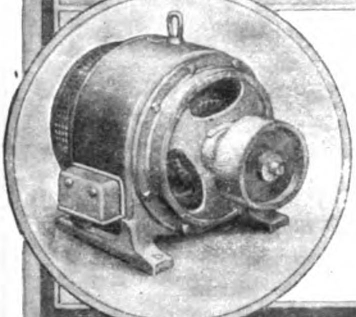

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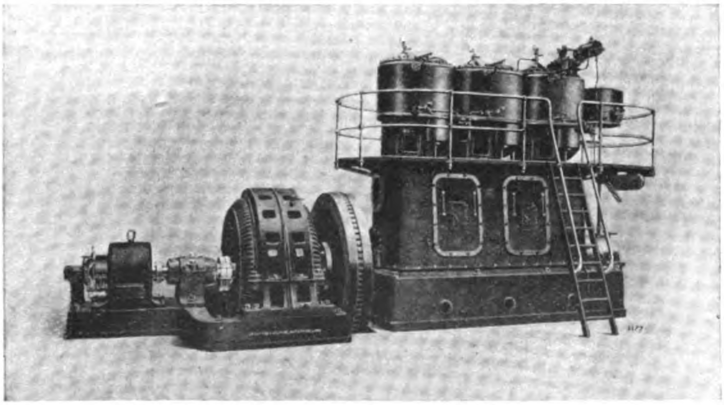

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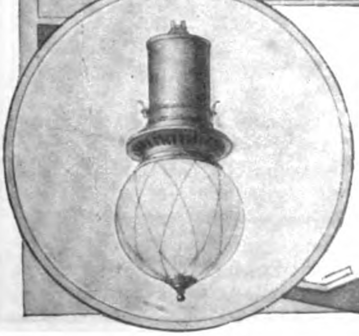

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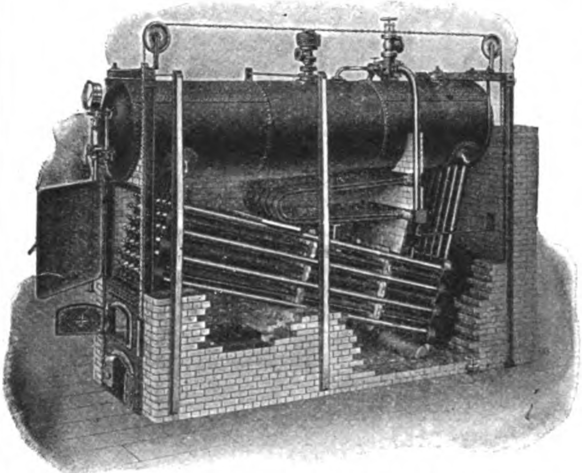

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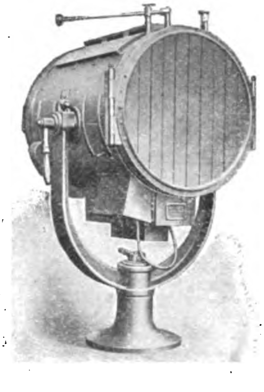

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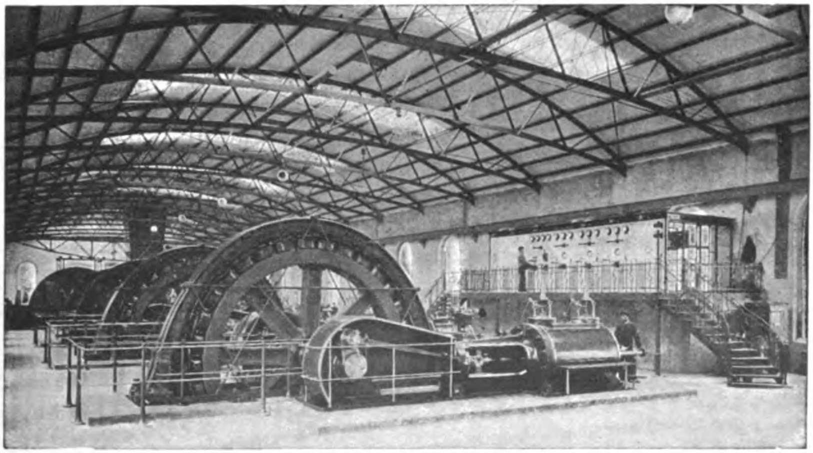

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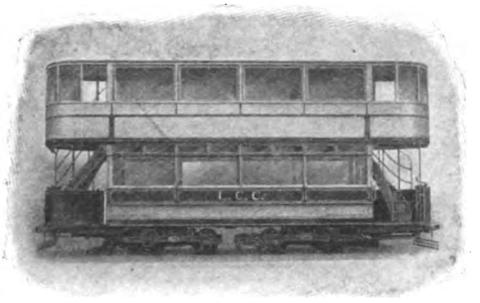

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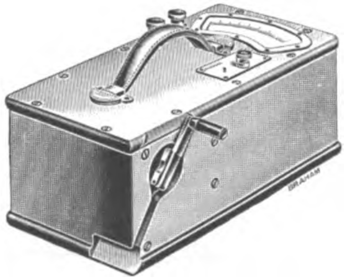

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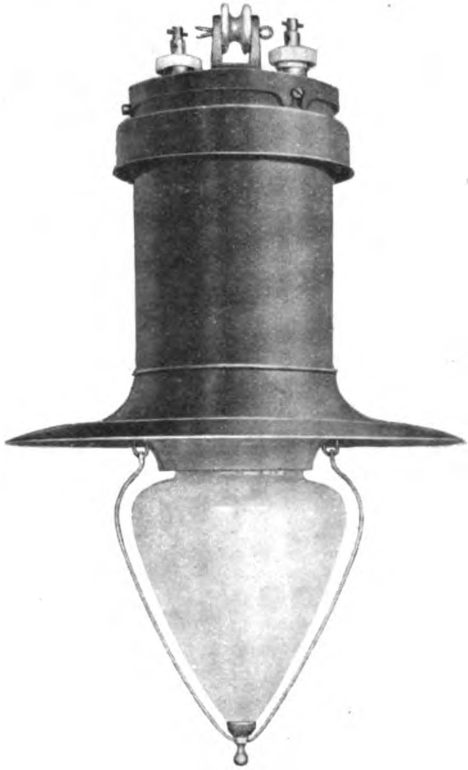

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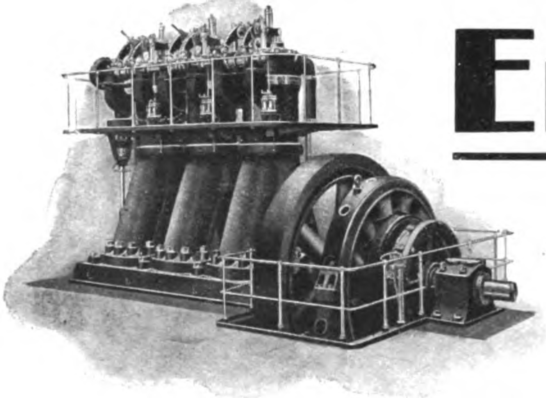

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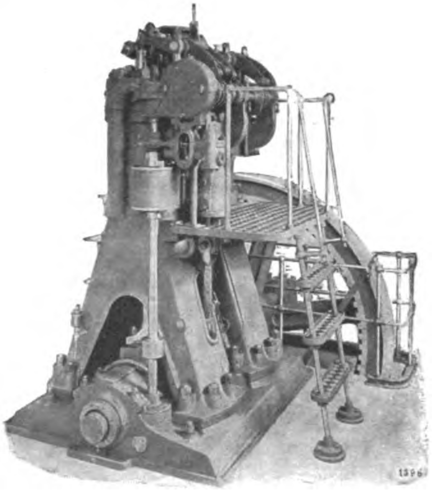

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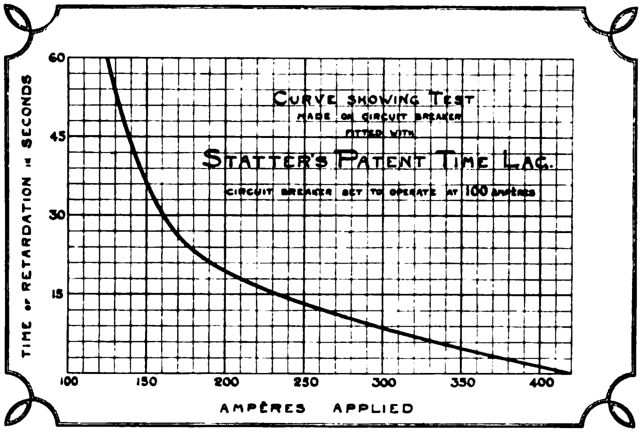

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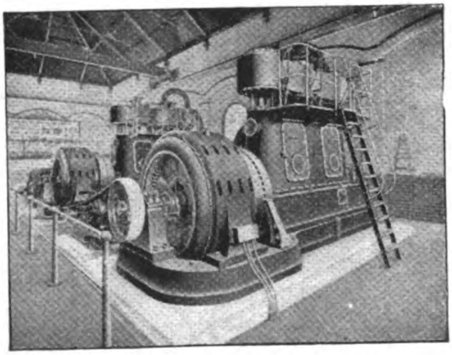

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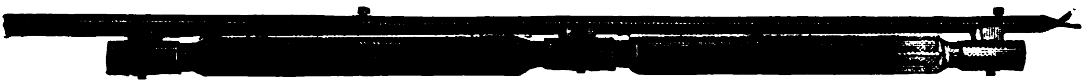

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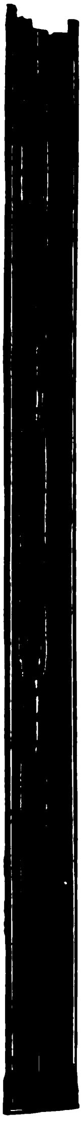

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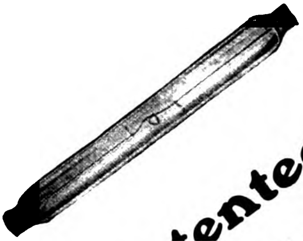

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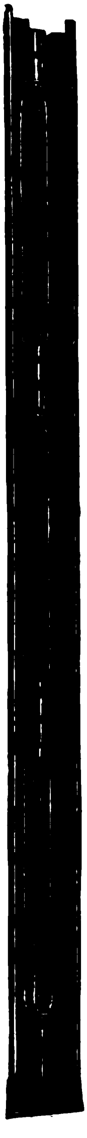

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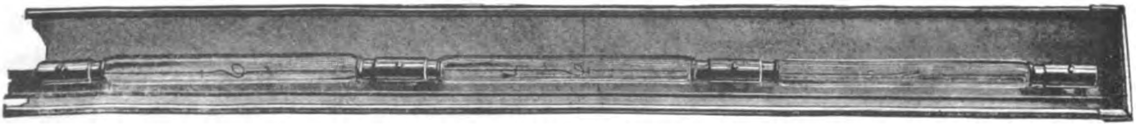

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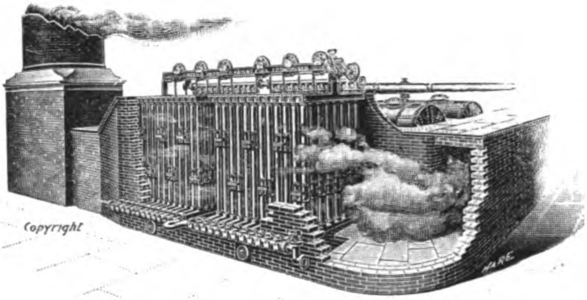

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The Electrical Magazine.

FOUNDED AND EDITED BY
THEO. FEILDEN.

VOL. VII. No. 3. (39th Issue.) LONDON. MARCH 30th, 1907.

The World's Electric Progress.

Colliery Number.

THE subject of electric power in collieries is a wide one, and of exceptional importance; apart from the ordinary economic advantages of applied electricity obtaining in the coal-mining as in all other power-requiring industries, there are special conditions in the "on-bank" and "in-bye" precincts of collieries which demand that electric power be used.

It is moreover in the equipment of collieries that the electrical engineer is called upon to supply the very best plant that his electrical and mechanical ingenuity and knowledge can devise. Careless, rough, and incomplete attention is more often than not the lot of colliery machinery; the duties of loads are, as a rule, of the most trying description; and, above all, there are the peculiar risks of explosive fires, floods, and falls to be coped with in the underground dark, dirty, and restricted roads and workings of the mine.

Consequently, no excuse need be offered to any reader of this journal, however little his interest in electrical matters may incline towards colliery practice, for the production of a number devoted solely to this one phase of the electrical industry. In the method of dealing with the subject, it has been thought advisable to take as the basis of the treatment descriptions and examples of actual installations, selecting such as are typical of modern practice and indicative of the tendency in development. It will be observed that the electrical equipment of the colliery has been divided into sections, each one dealing with some distinct branch of the subject. This arrangement facilitates comparison of the methods and the apparatus adopted by the leading manufacturers, indicating the choice available, and enabling one to judge as to the merits possessed by one or other type or system for each particular case.

⁂

The Evil of Trades Unions.

IN our last issue we had something to say regarding the manner in which trade unions retard efficiency and individualism, and thereby detrimentally affect the industrial and commercial interests of this country. At a luncheon given by the Robertson Electric Lamp Company, Ltd., recently, following an inspection of the factory, Mr. Hirst, the chairman, laid before the assembled technical journalists and newspaper men some facts which cannot be too widely known. He said that he and his directors had always endeavoured to maintain the most satisfactory relations between employer and employee. They did not change their labour frequently: they had done everything to keep the workpeople true and loyal. The workpeople, however, were not always the servants of the employer, but rather the servants of the Union, and Mr. Hirst went on to give a special illustration of the tyranny of trade-union tactics. As is well known, lamp bulbs are purchased generally from abroad, not being obtainable in this country. The Robertson Lamp people, having been in the habit of purchasing some £20,000 worth every year from the Continent, determined to see whether the bulbs could not be made and supplied in this country, and they approached the glass-workers in England, but could not come to terms with the Glass-Blowers' Union to enable them to compete with the foreign-made article.

Meanwhile, an old-established glass works having been closed down through the despotism of the Union, Mr. Hirst and his colleagues, with commendable ambition and foresight, offered to re-open the same for the manufacture of glass bulbs, and proposed to pay a reasonable rate for the blowing, namely, one shilling per hundred. The Union agreed, but it was then found that the men were not available; the Union having destroyed their trade, they could not be got together in sufficient numbers to start the factory. Presumably they had emigrated, or gone into other lines, or left the district, or were in the workhouse; anyhow the fact remained. Mr. Hirst then made an offer to teach the men on the basis of the above-mentioned terms if the Union would guarantee to keep to them, the Robertson Lamp people on their part guaranteeing to employ the said men. But no sooner had the men been taught the trade than they, through their Union, asked for a rise of fifty per cent., namely one and sixpence per hundred. Mr. Hirst appealed to the Union, and some sort of an armistice was agreed on, but the men soon afterwards made another demand, and the directors of the company were kept in a constant state of worry and anxiety. Mr. Hirst thereupon told the men that he had taught them their business, but he had had enough of it, and they could clear out. They did clear out. The indefatigable chairman, however, who was not to be beaten, engaged a few boys and put them in training, and in several weeks they were efficient. He then engaged more and more, and paid them a rate running to thirty shillings per week. This was less, of course, than the men were earning, but a pretty big wage for boys—too much in fact. Mr. Hirst preferred to employ married men who had families to keep, and he kept his eye on that the whole time. Eventually a number of the men who had been originally taught at the lamp works left the Union and gladly came back to the Robertson Company; they are now making £3 per week. More men followed, and the directors of the lamp works now have no difficulty with their employees.

The whole thing is an object lesson of the first magnitude. Mr. Hirst is to be congratulated upon the skill, energy, and resources he possesses to accomplish what has been done; it is not given to every manufacturer to be so fortunate, and this recital goes to prove how nonsensical, harmful, and vicious the trade unions are in advising the men. They cannot serve two masters. As has been repeatedly said, the unions have usurped functions for which they were not established, and they have made it well-nigh impossible in many cases for manufacturers to trade at a profit, driving a number of industries out of the country and throwing hundreds of men on the rates. We are not against trade unionism as such. Just the reverse. We firmly believe in protective co-operation both for men and for masters, and we cordially concede that many beneficial measures for the amelioration of the lot of workmen would never have seen the light but for the powerful combinations of organised labour which have sprung into existence in recent times and which have been instrumental in placing some restraint upon employers who hitherto had abused their work-people; but a restrictive hand upon grasping employers is one thing and tyrannical despotism is another, and it will be a bad day for this country if the powers of militant trade-union bodies which aim at the limitation of British labour and enterprise and the obtention of their own ends no matter what the cost, are not kept sternly and rigorously in check.

❧

A Progressive Industry.

As we have referred above to protective measures for workmen, we might with advantage mention that the chairman of the Robertson Lamp Works, in his speech dealt with in the preceding editorial, intimated that it was high time the employer was protected and gave it as his opinion that if there were ever so slight a duty upon imported lamps it would have the effect of preventing the organisation of the foreigner for this market, thus enabling the British manufacturer at the very least to double his output; the lamps would be made cheaper in consequence, the consumer would pay less, and naturally more British labour would be employed. Mr. Hirst further pointed out that taxation would be improved by a greater contribution spread over a larger area, which would relieve the local rates; also that by the cheapening of production we could enter neutral markets on as good as and probably better terms than our foreign friends.

The following facts will be found interesting. The Robertson Lamp Works at Brook Green were first opened for the manufacture of the Robertson electric lamp in the year

1893, Mr. G. Byng being chairman of the company. Mr. Byng retired in 1900 owing to ill health, and Mr. Hugo Hirst, the present chairman, joined the board. It was not until early in 1895, more than a year after operations had been started, that the first marketable glow-lamp was turned out from the factory, the intervening period being occupied in experimenting with and perfecting the Robertson lamp. On no fewer than five occasions since the original works were built has it been found necessary to make considerable extensions. At the present time, the Robertson electric lamp factory is by far the largest of its kind in the United Kingdom. The output of lamps is very much greater than that of any other British maker, being now nearly five millions per annum.

On the occasion of our visit, when we carefully inspected every department, we were struck with the great advancement in the system of production which had been made, and with the general efficiency and care displayed on every hand, both in the processes of manufacture and in the hygienic conditions of labour. We make no apology for drawing the attention of our readers to these facts in this manner, as it is only by efficiency and the full employment of the latest and most up-to-date methods, under healthful conditions, that British manufacturers can hope to retain and increase their trade.

* * *

Colonial Postage Reform.

A MOVEMENT is on foot which gives promise of far-reaching consequences. For a number of years past successive British Postmasters-General have been approached and petitioned with a view to reducing the postage on technical and other publications from the Mother Country to the Colonies, but all to no effect. The Editor of THE ELECTRICAL MAGAZINE nearly twenty years ago formed one of a deputation waiting upon Mr. Raikes, Postmaster-General at the time, and although influential pressure was brought to bear then and with each deputation since, no tangible result has accrued. It was hoped that the representations made to Mr. Austen Chamberlain would have been effective, but nothing was done.

The question of a cheaper postal rate for magazines and newspapers to the Colonies may perhaps not at first sight appear to be of any very great importance to readers, but nevertheless it is indeed a matter of the greatest moment. What are the facts? Let us take Canada, our nearest Britain beyond the Seas, and see what is taking place there in connection with this question. American manufacturers are enabled by the far-seeing business statesmanship of the United States Government to send their trade announcements in the technical and industrial journals over the border at the rate of *one cent per pound*. What does this mean? It means that the Canadian reader who is either merchant, trader, dealer, or consumer in some way or another, becomes more and more familiarised with the names and products of the United States' manufacturers, and more and more Americanised in his views and aspirations, echoing as it were the sentiments and practice prescribed by the American papers and trade publicists. This is having a dual effect upon the thoughts and feelings of aspiring and up-to-date Canadians, and especially upon the rising generation. Firstly it tends to produce a closer sympathy with American ideas—and this is insidiously, gradually, forcibly creeping forward, thereby lessening the bonds of kinship between Canada and England; secondly, this easy postal rate between the United States and Canada is having an enormous influence upon the trade of Great Britain. If only for the first reason assigned something should be done to counteract the peaceful but none the less baleful influences that are at work in favour of American thought and progress in Canada. Regretfully it must be said that the tone of the general papers emanating from the United States and placed so easily and inexpensively in the hands of our Canadian brethren is not all that can be desired. Many of the articles and illustrations are of questionable taste, levelled against Britain, and naturally in favour of America and her institutions. We do not say that the sentiments of every paper coming from America into Canada are so couched, but many of them most certainly are; and even those that are not openly antagonistic to British prestige naturally voice American ideas, and these ideas, good as they may be, are in every respect for our American cousin's welfare and cannot have the same influence for Britain's good as if disseminated by British journals. We have to retain not only Canada but every one of the British Colonies and Dependencies in possession of the most thorough and whole-hearted Imperial sentiment.

Dealing with the more practical side of this Postal question as it affects industry and trade, does it not strike our legislators that the cheaper technical and trade literature can be distributed in our Colonies, the greater the reflex benefit to our manufacturers? Whilst such papers as *The Electrical World*, of New York, can be sent to any part of the Dominion of Canada—our Dominion—for practically the value of an English halfpenny, it costs threepence to send a normal issue, and fourpence to sixpence a special issue of THE ELECTRICAL MAGAZINE, and similarly with other British technical papers. What it is necessary to drive home is that this class of paper above all others is pursuing an educational mission, but the British Post Office is restricting circulation and throttling the extension of trade, nay, more, to our irrecoverable loss, is encouraging and allowing the foreigner—for in this sense the citizens of the United States must be classed as foreigners—to steal a march on us and impregnate our Colonial brethren and would-be reciprocal traders with the very breath of their ideas culminating, in hundreds and hundreds of cases, in big business being done with the American manufacturer instead of with the Britisher.

The fact that it retards the remunerative circulation of our publications is another matter, affecting as it does the pockets of a large body of men who serve the public, but we shall not dilate on that. It is sufficient to know that British sentiment is being neutralized and British trade and industry is being lost wholesale. A most opportune time now presents itself for resuscitating this question and bringing it acutely to the front. With the visit of the Colonial Premiers comes the Hon. Rodolphe Lemieux, the Postmaster - General of Canada. Sir Hugh Gilzean-Reid, with Mr. C. Arthur Pearson and Mr. Upcott Gill, have seized the opportunity to call a meeting of London and provincial newspaper proprietors, and a most influential general committee has been formed, comprising a large number of the most conspicuous papers in contemporary journalism, both general and technical. From this general committee a small working sub-committee has been formed, and Mr. Theo. Feilden, the Editor-in-Chief of THE ELECTRICAL MAGAZINE, has had the honour of being appointed to this committee and of being entrusted with the interests of the technical press. A powerful deputation will shortly wait upon the British Postmaster-General, and Mr. Feilden would be glad to hear from readers of THE ELECTRICAL MAGAZINE — manufacturers or otherwise — who can give any practical evidence of trade being affected for the reasons stated or any information which may assist the cause at issue.

⁂

Commercial Motor Vehicles.

FROM March 7th to March 16th the first International Exhibition of Commercial Motor Vehicles and Motor Boats held sway at Olympia. There were some 250 exhibitors, and the great variety of finished conveyances and accessories shown afforded most striking testimony to the enormous development of this new industry. As one would expect, the petrol-motor was largely in the ascendant as the driving unit; yet there were many examples of the petrol-electric system to be seen, and it was very apparent that this combination is rapidly rising in favour. We have frequently discussed the merits of the electric motor drive and petrol power generation for road vehicles, and from time to time described new methods of application as they have been put forward by the manufacturers.

A distinct novelty in the way of arranging the electric motor drive of a petrol-electric omnibus was shown by Messrs. Greenwood & Batley. The driving unit is of special design, one extended field yoke accommodating the two armatures. The armature shafts are placed longitudinally on the chassis, the motor being hung by trunnions on the frame of the omnibus. The motor is thus free to swivel in transverse and longitudinal directions, each armature being coupled to a separate worm propeller shaft through a flexible coupling. The worm gear is totally enclosed; the worm being under the wheel ensures effective lubrication. By using two independent armatures, differential gear is avoided, and at the same time a perfectly flexible driving system is secured. The motor field is four-pole and series-wound. The control system introduces the series-parallel in conjunction with generator field regulation, which gives a very wide range of speed.

ELECTRIC POWER IN COLLIERIES.

Some General Electrical Points.

Having in mind the arduous conditions of electrical plant in colliery service, it will be readily appreciated that there are certain points making for reliability which must be exhibited to the fullest extent in apparatus intended for any mining duty.

The Home Office Rules, regulating the use of electricity in mines, are in every way admirable and necessary. Colliery men are ever coming into closer touch with electrical power matters, and there are now some few managers who can claim to be electrical engineers of more than average attainments. But there are still very many to whom applied electricity is a mystery to be dreaded, or, on the reverse, to be treated with callous indifference. The general mechanical equipment of the old colliery may be taken as typical of simplicity and regardless extravagance of material in engineering—few parts, slow speeds, and ponderous designs. Familiarity with such almost utterly unbreakable and everlasting plant has, to say the least, made the older school of mining engineer but indifferent custodians of modern electric motors, high-speed pumps, coal-cutters, cables, and switches. As a rule these worthy past-masters of the colliery industry have no inclination to start school again for an electrical course, and to them in particular the Home Office Rules came as a boon of priceless worth. There is now a letter of the law to follow, bewilderment and nervousness are practically banished.

These Rules are framed with the primary object of securing personal safety to the workers in mines, and of course the several stipulations control to a large extent the work of the electrical manufacturer and contractor; but there are many important properties of electrical colliery plant not influenced thereby, or, at all events, only indirectly.

It is when one comes to colliery practice that the feature of the ratings of electrical plant assumes the widest importance. It is essential that full guarantees of this nature shall be made and complied with throughout the whole installation. Electrical manufacturers are not by any means in agreement as to the ratings of totally enclosed motors even for everyday daylight and open-air services. The rise of temperature allowable in such machines is indefinite, and can only be so when the ordinary enclosed motor of to-day is originally designed as for open running and simply has the end brackets filled in for enclosed working. Furthermore, the general duty of a totally enclosed motor in a mine is either one of constant full load as for pumps, widely fluctuating but always heavy and continuous loads as in coal-cutting, or heavy loads for considerable periods as in hauling. Added to this there are the facts that ruling temperatures in the mine workings are higher than normal and that air space is restricted. It will therefore be seen how vitally important it is that the electrical equipment of a colliery shall be placed in the hands of electrical experts having experience of mining work.

In this connection too much stress cannot be given to the truism that the search for that which is cheapest in first cost is entirely wrong. To compare the price of a mining installation, quantity for quantity, with that of a surface installation, is absurd.

It is not necessary to go far into details to understand the reason of this and how disastrous the acceptance of the low-priced tender of an inexperienced contractor may prove to the purchaser.

It is not only in motors that high reserve powers or low ratings must be obtained, but in cables, fittings, switches, and indeed throughout the whole installation there is required perfection of material and exceptional strength.

Having all these desirable and, of course, price-raising qualities, there are still the unavoidable heavy rates of wear-and-tear. Ample spares must be kept in stock and the electrical work at the colliery must be in the hands of capable and experienced working electrical engineers.

There is a decided shortage in the number of skilled engineers who are well qualified in electrical power installation work and have mining experience. Here again the question of price comes in; the wages offered for such services are as a general rule much below those deserved and justified. It is very certain that a really good man can save his employers endless expense and anxiety, but such a man can make a better salary above ground in the sunshine—surely there must be some pecuniary bait extended to tempt him to spend his working hours in the depths of a mine. That there is in mining work a very promising field for the ambitious working electrical engineer is a certainty; electrical power is to-day entering into the working of collieries by leaps and bounds, the value of the right kind of mining electrician is being realized. The Home Office Rules recognize the importance of skilled supervision of electrical mining plant, directing that one or more qualified men shall be in constant attendance; but no hint is given as to what should constitute the qualifications. As a consequence there are collieries employing modern electrical plant but which are certainly not getting the full benefit from these simply because there is not a competent electrical man connected with the running of the plant. Engineers are required for this work, and that fact the colliery manager cannot afford to overlook.

In the erection of plant in-bye, particular skill is required of the engineer. Machines which in ordinary above-ground work would be assembled at the factory and transported and handled in one piece right to their foundations, often as not must of necessity be dismantled and conveyed piecemeal, and with more or less of difficulty, into the recesses of the mine. Not only is there the conveying of heavy yet delicate pieces through restricted passages and over rough, unlevel roads where the handy crane or lifting tackle cannot enter, but there is reassembling to be effected in some cramped dark corner, where the head-room will not always allow even of pulley blocks being used. Of course, all this scheming is familiar to the colliery man, but to the average electrical fitter it is at least trying, especially as with electrical appliances small clearances and accurate setting are essential and infinitely more important than was the case with the old forms of slow-speed primitive mining machinery.

The Electric Power Supply.

Most of the British coal-fields are now served with public electric supply companies from whom energy can be purchased in bulk; where a colliery avails itself of these conditions the first handling of electricity is a question of distribution and is covered in another section to follow.

Gas or Steam Units?

In those cases where the colliery is independent and is equipped with its own electric generating station, there is an almost infinite variety in the plant and systems employed. Even in the most recent installations there is considerable diversity and several main features of practice are far from being standardized. The familiar questions as to whether gas or steam shall be the engine power agent, and if gas whether it shall be alone and gas engines adopted, or whether, in conjunction with steam, it shall be burned under boilers, are, for instance, always in debate. Very often this matter is quickly decided owing to the presence of existing boilers and engines, the result being a moderate degree of economy and a saving in capital expenditure. Where entirely new plant throughout is to be purchased, there is always a series of important and somewhat perplexing comparisons to be made. The eventual decision depends largely upon the class of coal handled and also to no little extent upon the courage and enterprise of the colliery owner and his engineering adviser.

Where the coal mined is of the coking class there would seem to be no doubt as to the oven gas being the only really economical source of power. Here is a rich store of energy ready to hand as a bye-product, and in many cases in this country, but far more frequently abroad, due advantage has been taken of it. In some cases the colliery power requirements are comparatively small and the risks which many people still feel are encountered with gas engines may be avoided, ample power being obtained from coke-oven-gas fired steam boilers. It does occur however that to utilize the available gas in this round-about way will not yield the power requirements, and the gas engine becomes essential to secure the most economical power system. The large-sized gas engine has for a long time been mistrusted by the general engineer, and this is especially so when the duty in mind is the driving of alternators. This opinion is rapidly giving way as the number of gas-driven alternate - current power stations increases. It may be accepted as a fact that gas engines have proved to be in every way reliable and successful for driving alternators in parallel.

There is no occasion here to describe in detail the various styles of gas engines available for and in use at colliery electric power stations. The illustrations Figs. 1 and 2 show typical examples.

Gas Power Plant.

The Premier gas engine illustrated is of the single-cylinder scavenger type. The engine is so named because the products of combustion, which in the ordinary gas engine are allowed to remain in the clearance space behind the piston, are swept out by a charge of air forced through this clearance space in a positive manner. The incoming charge of gas and air is thus not contaminated and heated by burnt gases, but mixed with pure and cool air which can support combustion. Not only is this engine therefore very suitable for the use of poor and weak gas. but it is specially adapted also for the use of rich gases, such as coke oven gas, because the charge of scavenging air sweeps out lingering flame from the clearance space and replaces the hot products of combustion which in other types of engines frequently cause premature ignitions, more especially when working with rich gases. This feature of clearing out the whole of the products of combustion after each cycle also permits of higher compressions and lower initial temperatures being secured with the cylinder charge, thus ensuring an exceptionally good thermal efficiency for the engine.

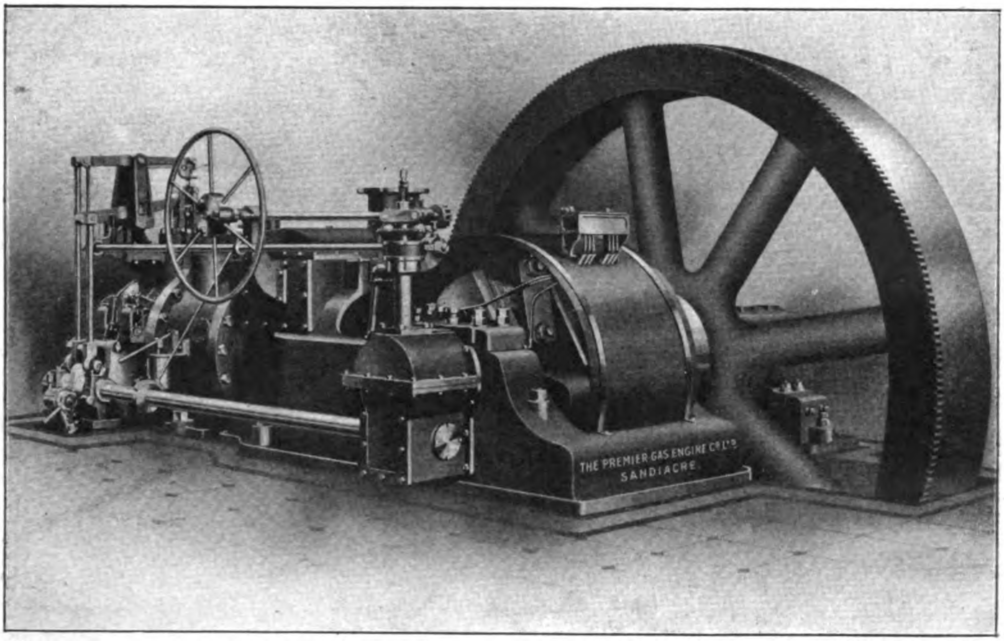


Fig. 1. A "Premier" Gas Engine.

The governor is of the high-speed spring loaded type and is very sensitive, being extremely powerful and fitted with ball bearings throughout to reduce friction. It is driven direct from the crank-shaft. The motion of the governor is conveyed by means of an oscillating shaft, also carried in ball bearings, to a blade which swings freely on a pivot in the end of the gas valve lever, and engages with a notched block. This block is attached to a short lever, in such a manner that the blade engages with the notch nearest to the fulcrum when the governor is in its lowest position, and as the governor rises, it engages with notches farther away from the fulcrum, thus varying the lift of the gas valve and the quantity of gas admitted. When the blade is moved to the greatest extent, it misses the plate altogether and no gas is admitted. This constitutes a combined variable-combustible and hit-and-miss arrangement, the latter coming into play only at light loads when the variable governing alone would be very uneconomical. With this arrangement very steady driving is obtained, and engines so governed run direct-coupled dynamos in parallel with very satisfactory results.

The Westinghouse gas engines are of several types; the one illustrated is the best-known form, having three cylinders, each working on the Otto cycle and governed on the principle of regulating the amount of correct explosive mixture admitted to the cylinders per cycle. The turning movement of the engine is remarkably uniform and it has proved very successful for the parallel driving of alternators, direct-coupled.

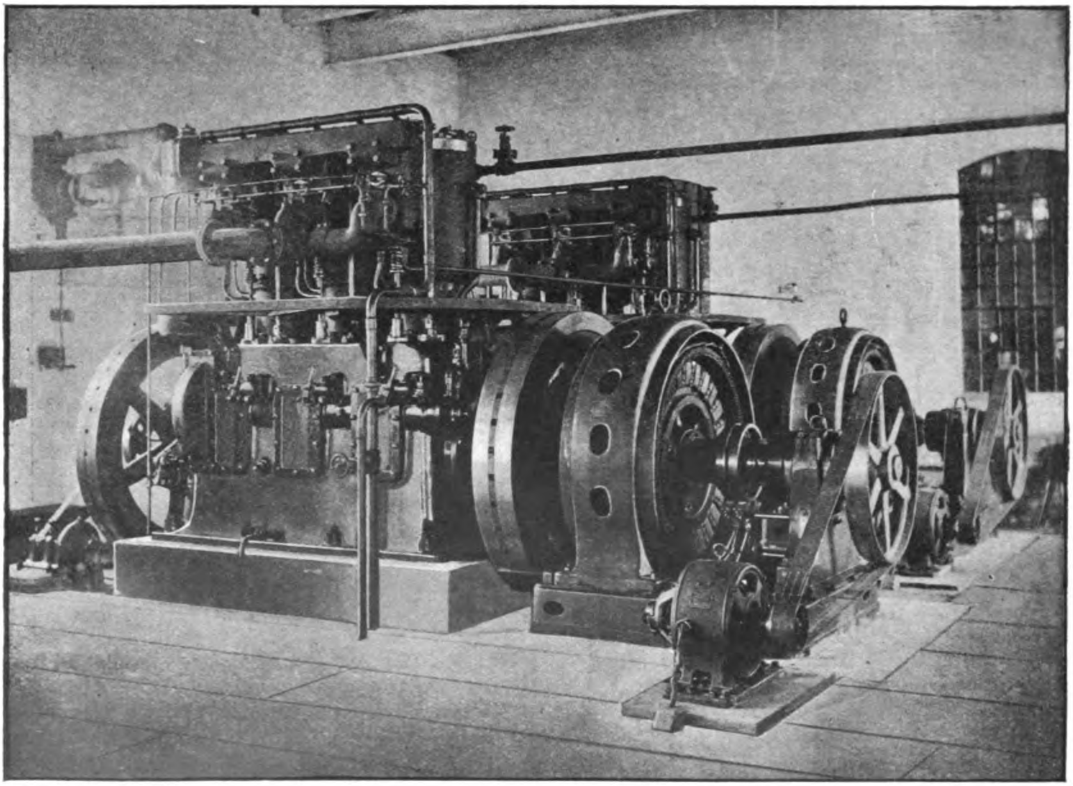


FIG. 2. WESTINGHOUSE GAS ENGINES DRIVING ALTERNATORS.

In the development of this class of power-generating station the one great hindrance has undoubtedly been the heavy first cost of installation. The price of patent coke-oven plants and their accessories has deterred many who would freely have adopted this remarkably economical process of obtaining coke, sulphate of ammonia, tar, and benzine, and an abundance of electrical power. It may indeed be said that only the wealthiest and largest colliery properties can embark on such a wide-reaching innovation. Nevertheless there are quite a

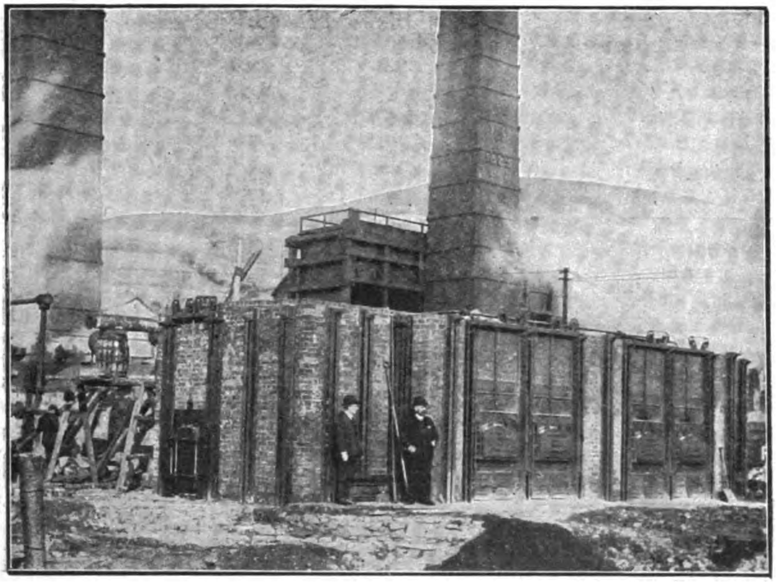


Fig. 3. Meldrum Destructor Furnaces at North's Navigation Collieries, South Wales.

number of our most important collieries so equipped, in the North, in the Midlands, and in Wales. Where a group of collieries is under one ownership a central patent coking plant and a common gas-electric power station alongside forms the ideal of economical working.

Steam Power Plant.

In considering the subject of steam power at collieries the general impression is that considerable progress is now being made towards securing high fuel economies. It is remarkable that until quite recently it was customary to draw lavishly from the good saleable product of the mine and consign as waste to the pit-heap vast quantities of material which, although so poor as to be generally unsaleable, is a quite workable low-grade fuel. It is very obvious that at the pit marketable coal is priceless as compared with waste which, when deported to the tip, has a negative value. Consequently it is in connection with collieries that there are found the most modern equipments for getting the last ounce of useful work out of the most refractory grades of coal fuel. Destructors, patent furnaces, automatic stokers, forced draughts and similar appliances are all in constant demand and exemplify the great awakening which has gradually come in the past few years to the British coal-master.

Prominent amongst the many devices for dealing successfully with the lowest-grade fuels are the Meldrum furnaces, of which many hundreds are in use at collieries in this country and abroad. These furnaces are adapted for application to all classes of boilers, including Lancashire, Cornish, vertical, and the various water-tube types. The general principle, employing superheated steam jet blowers, is well known to all engineers. The illustrations

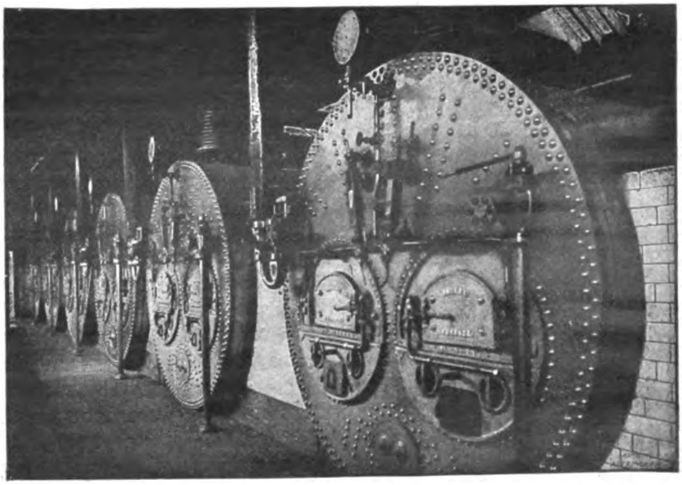


Fig. 4. Lancashire Boilers Fitted with Meldrum Furnaces, Haydock Collieries, St. Helens.

Lancashire Boiler, 30ft. × 8ft.; Heating Surface, 1000 square feet; Grate Area, 38 square feet.

Duration of Test	Class of Fuel Employed	Total Fuel Burnt (Lb.)	Fuel per Hour (Lb.)	Fuel per sq. ft. of Grate per Hour (Lb.)	Temp. of Feed Water	Total Water Evaporated. (Lb.)	Water Evaporated per Hour (Lb.)	Water Evaporated per lb. of Fuel (Lb.)	Water Evapt. per lb. of Fuel from & at 212° F (Lb.)	Steam Pressure (Lb.)
6 hrs. 50 mins.	½ Coke Dust & ½ Peas	5720	837	22	130° F	42360	6199	7.4	8.2	70
8¾ hours	do.	7080	809	21	180° F	45380	5186	6.4	6.78	50
7 ,,	½ Pickings & ½ Settlings	5220	745	19	,,	42120	6017	8.0	8.48	75
4¾ ,,	Pond Settlings	4800	1010	26	,,	25600	5389	5.3	5.6	70
6 ,,	¼ Coke Dust & ¾ Peas	5700	950	25	,,	52360	8726	9.18	9.73	80
5 hrs. & 10 mins.	⅓ Peas & ⅔ Pickings	4080	789	20	,,	34680	6712	8.5	9.0	55

herewith are of typical colliery installations.

Fuel Economy.

One of the largest colliery firms in South Wales, Messrs. Nixon's Navigation Collieries, has now in use sixty-five boilers equipped with these furnaces, which enabled them to burn their cheapest Duff and washery refuse in place of a good saleable small coal formerly used. Another example is the Wigan Coal & Iron Co., Ltd., who have 29 boilers fitted. Here, also, the furnaces are burning the smallest coal-dust and giving excellent steam-raising results therefrom.

The above figures are of tests made a few years ago at the Barrow Collieries, Barnsley, on one boiler fitted with the Meldrum system, and burning various classes and mixtures of refuse and cheap coal. After these tests a number of other boilers were fitted at these collieries, and last year four further orders were given for similar equipments.

At several collieries even worse classes of fuel are used in conjunction with Meldrum external destructor furnaces, which are similar to this firm's well-known type of ordinary town refuse destructor. Such material as shale, pickings, coke-oven dust, pond settlings, &c., are efficiently dealt with: this material is frequently of too poor calorific power to be utilised on the limited grate area of the usual type of internal furnace, but the external furnaces introduce grates sufficiently large to burn such a weight of refuse as will compensate for its low quality and secure the full output of steam from the boiler. Fig. 3 illustrates an installation of this type at North's Navigation Collieries, South Wales.

In this case the makers are said to have guaranteed to evaporate 700 gallons per boiler per hour, under a heavy penalty in the event of this not being attained; but from the following particulars of the tests it will be seen that the actual results were far ahead of the guarantee:

Duration of test	8 a.m. to 9 a.m.	12 noon to 4.30 p.m.
Fuel used	Coke breeze and pond settlings.	Coke breeze and pond settlings.
Water evaporated (total)..	1872 gallons.	7400 gallons.
Water evaporated (per hour)	,, ,,	1620 gallons.
Temperature of feed water	40° F.	40° F.
Temperature of atmosphere	45° F.	45° F.
Steam pressure	125lb.	125lb.
Fire	Clean at start.	2 furnaces cleaned during test.

The standard Meldrum furnaces, as fitted to a range of Lancashire boilers at the Haydock Collieries, St. Helens, are shown in Fig. 4. A last year's report of the Manchester Steam Users' Association gives full details of trials made by them on a boiler so equipped at Haydock Collieries. A much finer and lower quality fuel was used in these furnaces on the test than with ordinary firing, and the Meldrum system produced fully as much steam from the inferior fuel, thus giving a very marked economic advantage.

To handle coal and ash cheaply, as well as to utilise a low grade of fuel, represents the high-water mark of efficiency in steam generation. The Carlton Main Colliery Company, Ltd., of Barnsley, have recently laid down installations supplied by Messrs. Ed. Bennis & Co., Ltd., which are typical of the best modern practice. Coal and ash-handling plant, including mechanical stokers, has been installed at the Grimethorpe Colliery. The boilers number eighteen—twelve of the Lancashire type and six of the Cornish type. The complete range of boilers is supplied with machine stokers, fitted with pneumatic gear and self-cleaning compressed-air furnaces, which are adapted for burning a low-grade slack, such as in many instances is thrown to waste in collieries. The fuel is delivered into the stoker hoppers by means of a combined elevator and conveyor. This combination consists of a channel-shaped trough, of close hard-grained cast iron, ⅝in. in thickness, and strongly ribbed, 9in. in width and 6in. in depth. The conveyor chain consists of a series of **U**-shaped links, of 2in. by ½in. open-hearth acid mild steel flats.

Under the coaling line, at a distance of about 50ft. from the centre of the first boiler, is a coal bunker formed in brickwork. From this bunker, through a cast-iron shoot, the coal is delivered on to the inclined portion of the conveyor trough, thence it is elevated, conveyed, and distributed through the shoots into the mechanical stoker hoppers. The speed of the chain can be adjusted to suit the fuel consumption, even though the demand may be very intermittent.

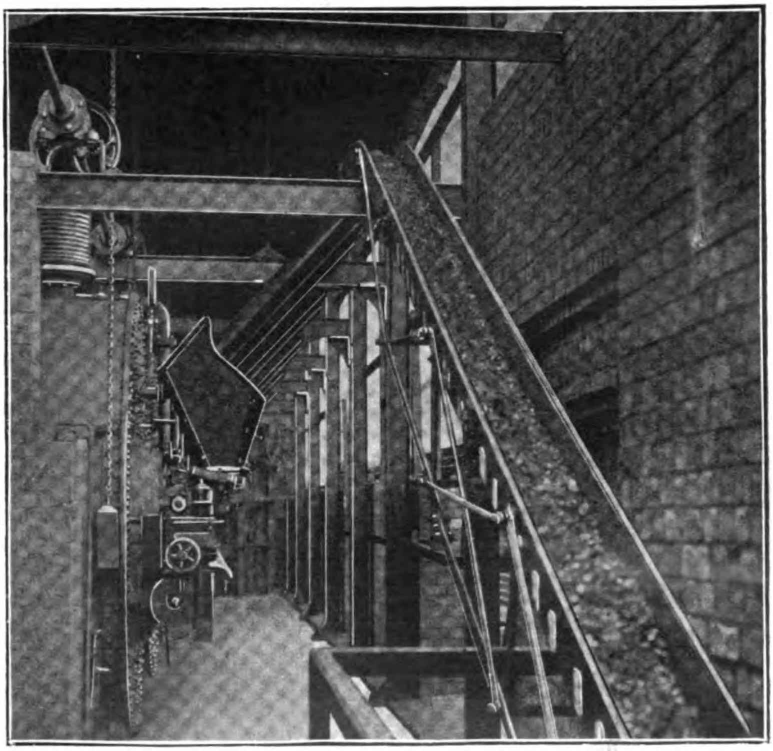


Fig. 5. Bennis Stokers and Compressed Air Furnaces and Elevating and Conveying Plant at Frickley Colliery.

The return chain is led back over the top of the conveyor trough, and supported on cast-iron rollers with chilled peripheries. The return chain in most cases is utilised for conveying the ashes, but in this particular instance, owing to inequalities of the boiler floor, this could not readily be arranged.

The furnaces of the stokers are of the self-cleaning type, the clinker and ashes being delivered over the bar ends into a chamber in the boiler furnaces; from this chamber the clinkers are drawn out by the boiler attendant by means of a specially constructed shovel, and delivered in small heaps immediately in front of the boilers. Thence they are shovelled into a travelling tub. When the tub is full, it is pushed along, and the contents tipped into a small hopper, arranged beneath the boiler house floor in the centre of the length of the boiler house. From the hopper the clinker is elevated by means of a similar conveyor to that used for the coal, and delivered through two swing shoots into a railway truck standing underneath. These shoots are hung and balanced, so that they can be swung up out of the way.

The amount of power taken by the whole plant is exceedingly small. The whole of the mechanical stokers, together with the coal and ash handling plant, are driven from a 2½in. diameter line shaft, running in self-oiling bearings. From actual indications, the amount of power necessary to drive the whole plant varies between 12h.p. and 15h.p.

Since this plant has been installed, a

much inferior quality of slack has been used to that previously found necessary for hand-firing. Over and above this, sufficient steam can now be obtained from the twelve Lancashire boilers, the six Cornish boilers being out of service as stand-by plant. The number of men necessary to look after the complete plant is three per shift, considerable saving having been made from this source. It is interesting to know that the entire plant was installed and handed over in four weeks.

At the Frickley Colliery, the sinking not being quite finished, Messrs. Bennis had the opportunity of considering their scheme while it was on paper. The result was that they found that although the Colliery Company had allowed for twenty-two boilers, experience with the Grimethorpe plant warranted the reduction of the number of boilers from twenty-two to seventeen, thus effecting a saving of five boilers and brickwork, which was considerably more than would pay the cost of the complete equipment of mechanical stokers and conveying plant for the seventeen boilers.

During the sinking operations, six boilers only were installed; these being supplied with machine stokers fed with combined elevator and conveyor, similar in design and construction to the installation at Grimethorpe.

The amount of power taken to drive this plant is as low as 3b.h.p. Here it may be noted that the mechanical stokers require ½b.h.p. per boiler to drive them At the present time the plant is easily looked after by two men.

In the case of the Carlton Main Collieries there are eleven Lancashire boilers fitted with "Bennis" stokers.

As at Grimethorpe and Frickley, the fuel is delivered into the stoker hoppers by the combined elevator and conveyor. The coal-receiving bunker is formed under a loop line, taken out of the main coaling line, and is built underneath at a distance of about 75ft. from the centre of the first boiler. From this bunker through a cast-iron shoot the coal is delivered on to the conveyor and thence distributed through shoots into the stoker hoppers. The return chain of the conveyor is utilised for conveying the ashes, and runs in a similar trough to that used for the coal. It is fixed in a small brickwork culvert under the boiler-house floor plates.

The amount of power necessary to drive this portion of the plant is 2b.h.p., and it is only necessary to run this for a short space of time, say morning and afternoon, when cleaning out the clinker chambers of the boiler furnaces.

The maximum speed of the conveyor chain is about 30ft. per minute, and this speed may be regulated as required by any of the boiler attendants. The chain may also be brought to a standstill or started with equal ease. This group of boilers is operated by three men as against seven in hand-firing.

Since the installation of this plant, screenings from the slack that was used in hand-firing have been utilised, thus effecting a considerable saving. The steaming capacity of the boilers has also been increased by 25 per cent., two important economic factors being thus secured.

Most of the up-to-date collieries are now making use of economisers to reduce the working expenses of their boiler plant. One of the numerous installations recently erected is shown in the illustration on the next page. This is at Messrs. A. Knowles & Sons', Ltd., colliery, Pendleton, Manchester. There are five boilers at work with a Green's economiser of 384 tubes, and at the time the last test was taken, the gases were: entering the economiser, temperature 340deg., leaving 280deg.; feed water entering the economiser was 90deg., being delivered to the boilers at 300deg. This shows a recovery of 210deg. from the waste heat in the gases, and put into the feed water. It is unnecessary to point out the saving thus effected. The initial outlay is soon repaid by the increased economy. There is a large additional heating surface, in many cases equal to an extra boiler. The supply of high-temperature feed water at a uniform pressure makes for greater efficiency and steaming power of the boilers, and unequal expansion and contraction are prevented. Moreover, there is always a reserve of high temperature available in the event of a sudden call for extra power.

It may be said that, so far as steam engines are concerned, the present-day tendency in colliery electric power houses is to follow the lead of the public central station, and to instal enclosed high-speed vertical engines or steam turbines for the direct driving of the dynamos. In very many cases, however, the electrical machines are driven by ropes or belts from the older slow-speed types of

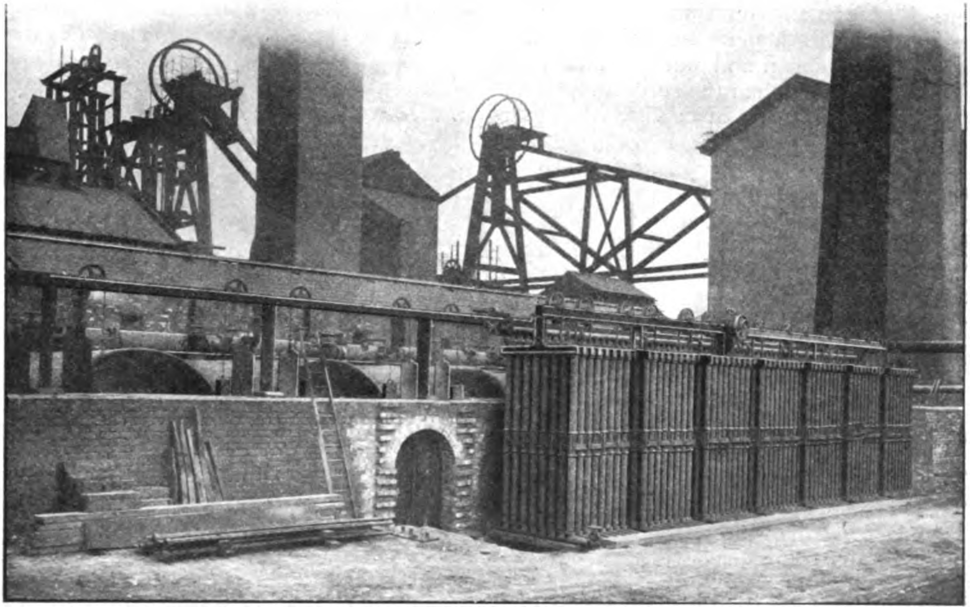


FIG. 6. THE GREEN'S ECONOMISER PLANT AT MESSRS. KNOWLES' COLLIERY, PENDLETON.

horizontal engines. It is not necessary to dilate upon the several types of steam prime movers available and adopted.

Steam Economy.

The inborn faith of the colliery man in everlasting, slow, and heavy machinery probably accounts for his tardy acknowledgment of the merits of high-speed engine and turbine; but a change has taken place of recent years, and he is now satisfied that even light and quick-running machines can be altogether relied upon for hard service, and, furthermore, that they are a great means of economy. In pursuit of this latter, mention has been already made of the steps commonly taken in the boiler house. The same enterprising spirit is revealed in the engine room equipment, where the condensing of exhaust steam is now becoming as frequent as until only a year or two ago it was rare.

Condensing at once suggests itself as one of the most important factors in the question of saving, and provided that the subject is carefully gone into by experts in this class of work, there is no reason why great economy should not be attained either by condensing the exhaust steam or by utilising it for driving a low-pressure turbine after it is discharged from the reciprocating engines.

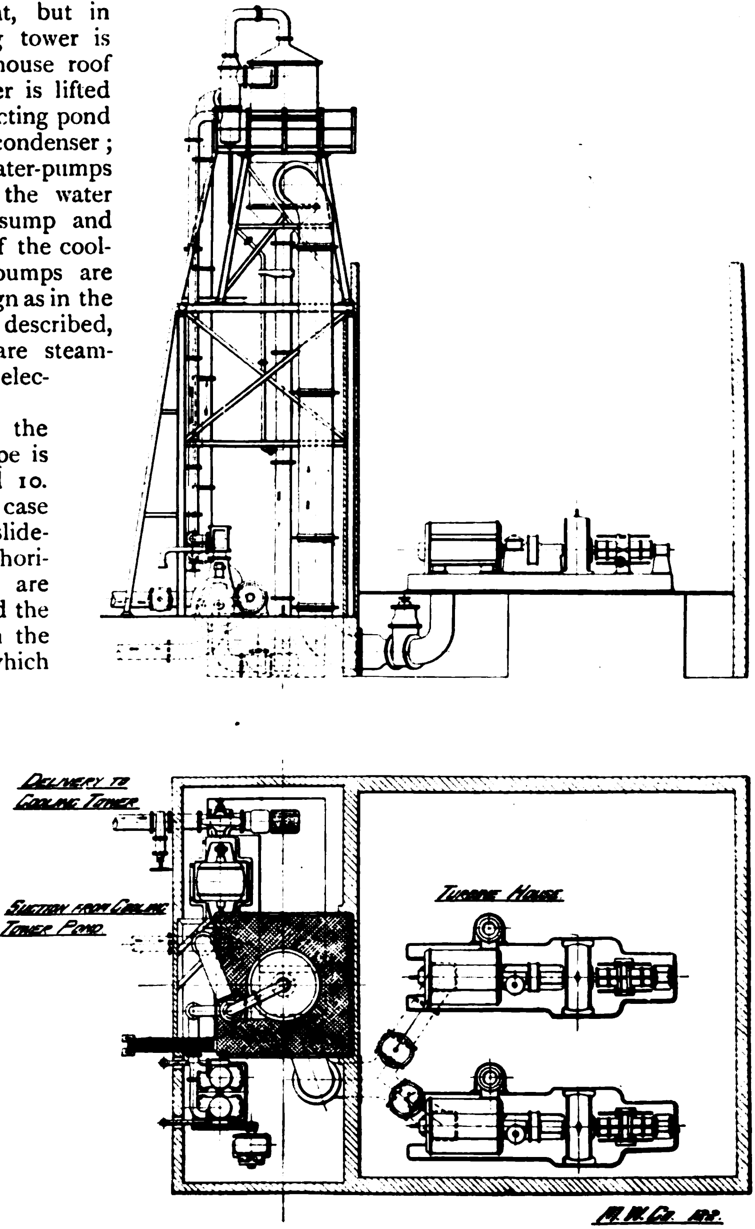
We recently had the privilege of visiting the works of the Mirrlees Watson Company, Ltd., Glasgow, and were much interested in the number of condensing plants which this firm had in hand for collieries and steel works. As showing the perfection which has been attained in the design of apparatus for usefully dealing with exhaust steam, the accompanying illustrations of several types of plant made by this well-known firm will no doubt be of interest.

Figs. 7 and 8 illustrate a plant of the elevated self-draining jet type: it is attached to two exhaust steam turbines which take their steam at a pressure of one or two pounds above atmospheric pressure as exhausted from a set of rolling mill engines; between the engines and the turbine there is a heat accumulator on the "Rateau" system, which has the object of reducing the intermittent rushes of steam to a steady flow suitable for operating the turbine. A cooling tower is used in this installation and there are two centrifugal water pumps, one delivering the injection water from the cooling pond to the condenser, the other transferring from the condenser sump tank to the tower.

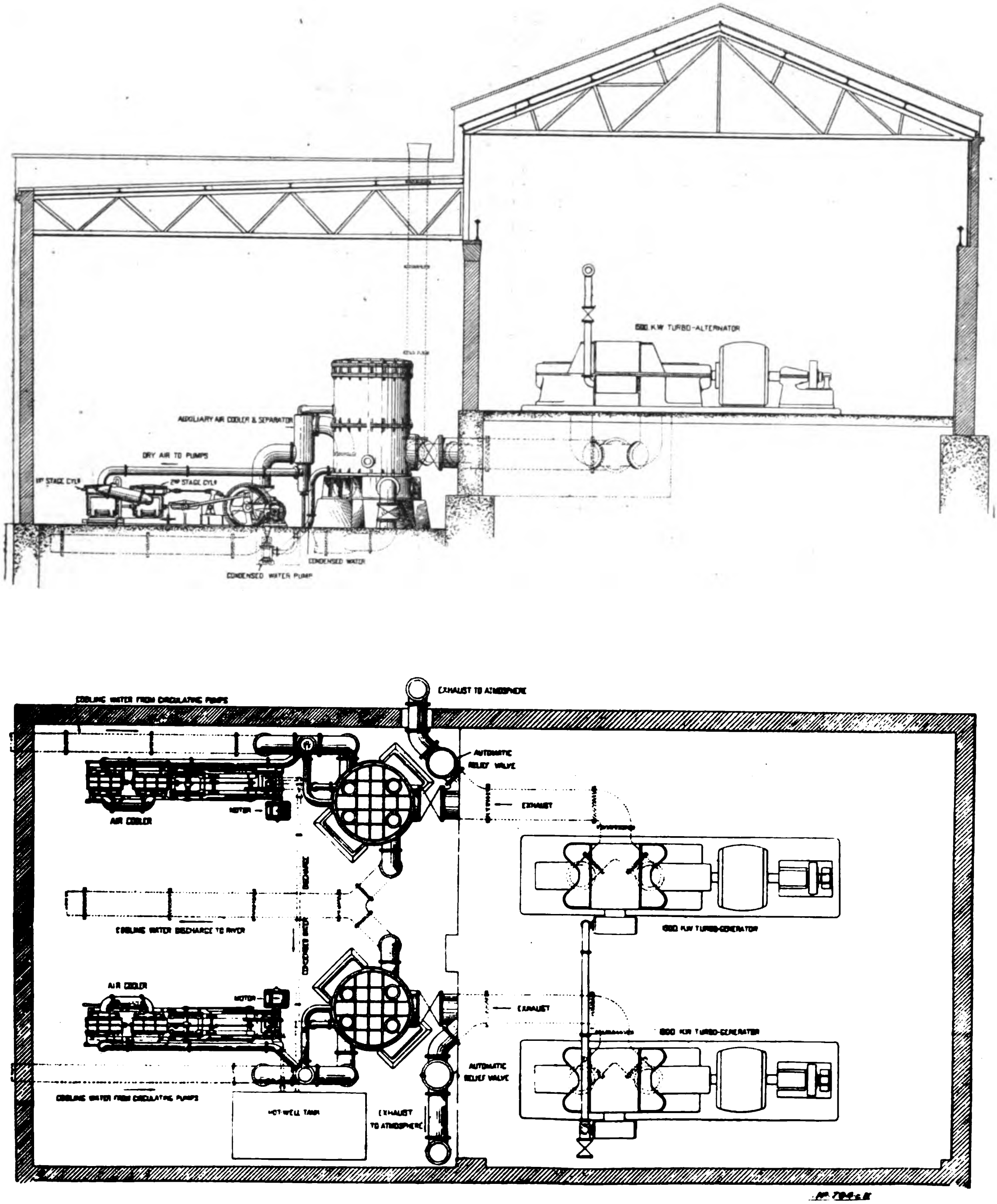
The air-pump is of the slide-valve type and deals with dry air only. The condenser contains an ingenious but simple arrangement of tray for giving a perfect distribution and contact of the steam and water. This type of plant is cheaper than the surface type and requires a less quantity of cooling water per pound of steam condensed Fig. 11 shows another arrangement of elevated jet plant, but in this case the cooling tower is fixed on the boiler house roof and the injection water is lifted out of the tower collecting pond by the vacuum in the condenser; thus only one set of water-pumps is required to raise the water from the condenser sump and deliver it to the top of the cooling tower. The air-pumps are exactly the same design as in the installation previously described, excepting that they are steam-driven instead of by electric motors.

An installation of the surface condensing type is shown in Figs. 9 and 10. The air-pumps in this case are also of the dry slide-valve type, but of horizontal design; there are two air cylinders, and the air compression is on the two-stage principle, which gives the highest possible vacuum. The circulating pumps in this installation were placed near the river. If the water is very dirty, necessitating frequent cleaning of tubes, a special form of top-water head is adopted and is so arranged that the tubes can be cleaned whilst the plant is in operation.

When a condensing plant is connected directly to engines discharging the steam intermittently it is necessary that the condenser be so designed that it has a large water capacity and at the same time a very large surface of water for contact with the steam, and the condensers which we saw were specially designed to meet these arduous conditions, and exhibited many particular features adapting them to the severe duties of this class of work.



Figs. 7 and 8. Elevated Self-draining Jet Condenser and Low-Pressure Turbines.



FIGS 9 AND 10. A TYPICAL MIRRLEES-WATSON SURFACE CONDENSER INSTALLATION.

Water Treatment.

The question of a pure water supply for boiler feeding is always with us, and nothing has tended more to the installing of water-softening plants than the increased working pressure of steam boilers. Many waters that are more or less satisfactory at a pressure of 80lb. per square inch give great trouble with boilers working at 120lb. The trouble is due not so much to the loss of fuel as to the very heavy wear and tear on the boilers caused by over-heating plates.

Collieries are especially subjected to such troubles on account of their water supply being so often exceedingly hard.

The "Criton" water softener, made by the Pulsometer Engineering Company, Ltd., of Reading and London, is intended to overcome these troubles, and these plants are doing exceedingly good work both in collieries and in general electric power stations. The illustration on page 133 shows a plant as installed at a colliery and dealing with 6500 gallons per hour of water from the jet condenser. It has been at work some years, giving entire satisfaction.

Space has prevented the inclusion in this issue of illustrations showing the "Criton" plant in section, but its main features of operation are the exact feeding of the correct quantity of reagents by actual measurement and its ability to run at varying speeds without adjustment. Special attention is also paid to the removal of the suspended matter, caused by the softening process, which is effected by a separate filter cleaned in position without any removal of the filtering material.

Amongst plants recently put to work by the Pulsometer Engineering Company are two for the Great Western Railway Company having an hourly output of 10,000 and 15,000 gallons respectively, and two plants of 11,000 gallons per hour for a well-known North Country firm, besides many smaller ones for electric light stations, &c.

Alternate Current or Direct Current?

The question as to whether alternating current or direct current is to be preferred for colliery work has practically resolved itself in favour of the former. After all, this is not surprising when one considers that the great bulk of power required in-bye can be effectively undertaken by polyphase motors, so that the particular features of the alternating-current system—*i.e.*, economical and convenient current transmission over long distances and simple non-sparking, non-commutator motors—are in themselves sufficient to justify its universal adoption as the primary form of current generation.

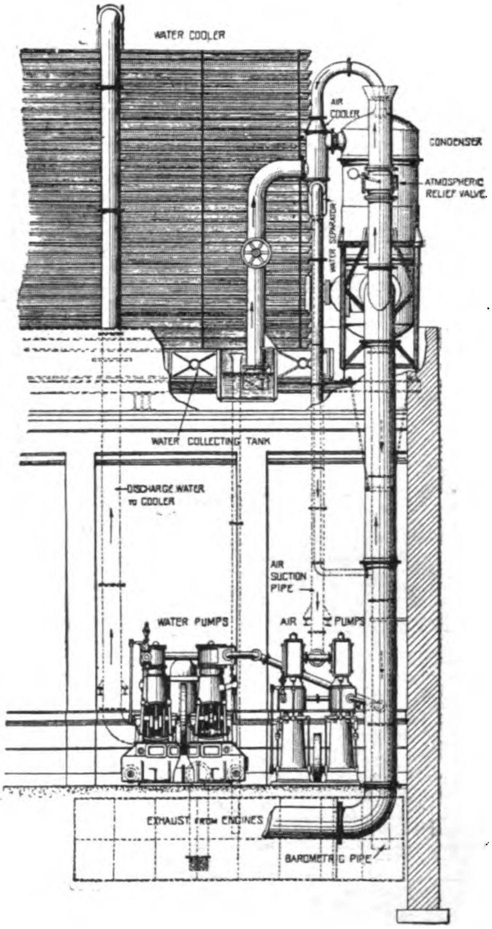


FIG. 11. ELEVATED JET CONDENSER.

There are, however, certain classes of power work in mines which are better suited for direct-current motors. In the case of traction by locomotive, up to the present, direct current is indispensable, but there has been very little demand for such work in this country; moreover the Home Office Rules stipulate that should an earthed return be used for any purpose the current supply for that service shall be independent of the general electrical system. This would seem to set aside at once any tendency to embark on a direct-current system because of locomotive traction being desired as part of a colliery electrical equipment.

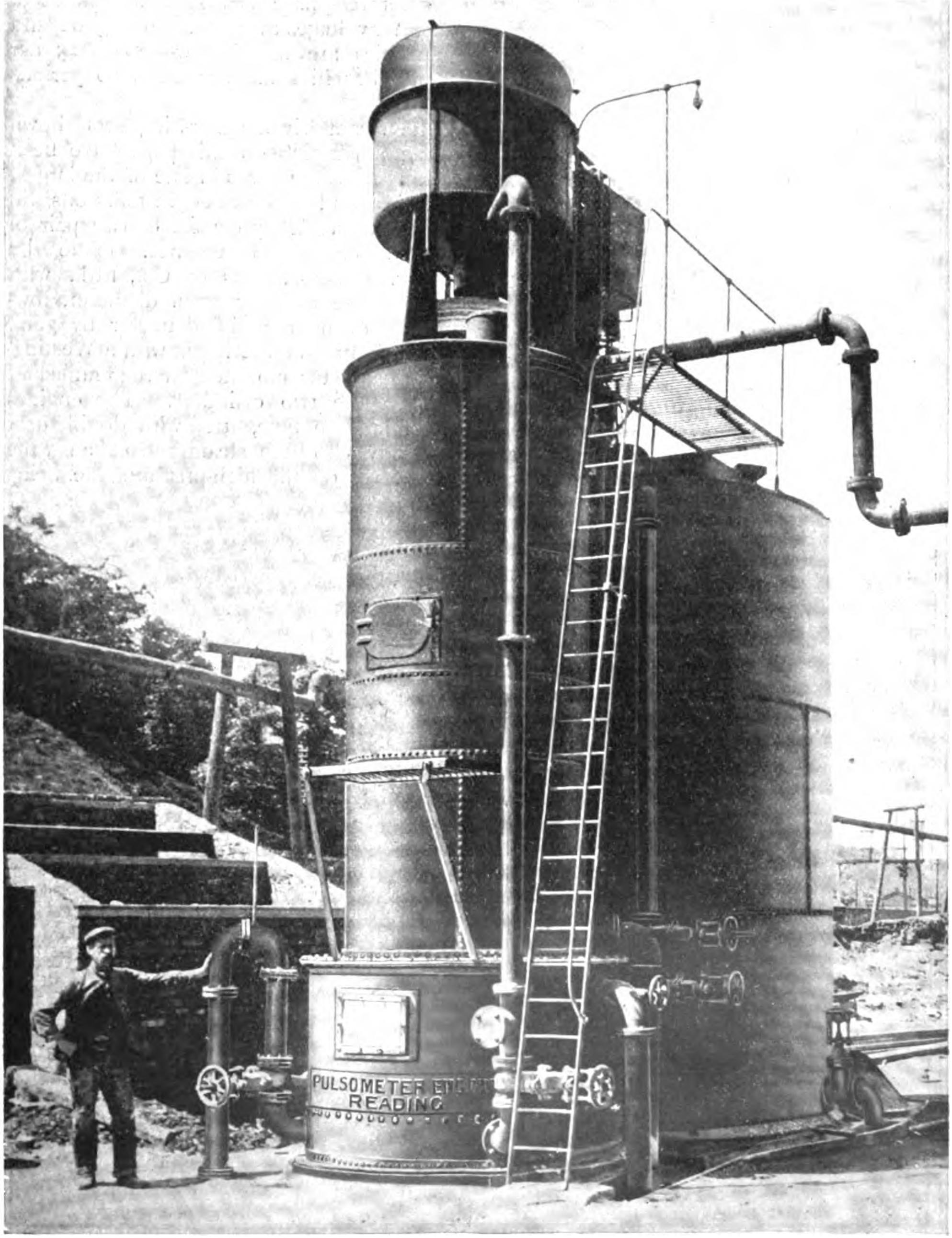


FIG. 12. A "CRITON" WATER-SOFTENING PLANT. CAPACITY 6500 GALLONS PER HOUR.

There has also been a long-sustained objection to the use of the alternate-current motor for coal cutting ; this is rapidly giving way before the extending successful use of improved types of alternating-current driven cutters. In short, it may be taken for granted that wherever a varied and thorough system of electrical power is to be adopted, alternating-current generation is desirable and should direct-current be deemed preferable for any particular purpose, either the exciter circuit or a.c. to d.c. conversion plant should be utilised. Such indeed is the practice which is indicated as being universal in future developments, although as will be gathered from these pages there is a very wide-spread use of the direct-current throughout.

Electric Generating Plant.

The average public central station is typical of the colliery power-generating plant. In direct-current systems the generating pressures are from 250 volts to 500 volts, and the dynamos are of standard shunt or compound types. In alternating-current plants, three-phase is almost always used, generator voltages average 2000 to 3000, and frequencies are usually low—20 to 25 per second, but in some few cases 50 periods is used.

The steam-driven generating sets shown in the illustration on this page have been working for some years in one of the largest collieries and ironworks installations in South Wales. They consist of two pair of coupled compound engines, made by Messrs. Marshall, Sons & Co., Ltd., with high-pressure cylinder 13in. diameter, low-pressure cylinder 22½in. diameter by 36in. stroke, running at 100r.p.m., with a Westinghouse generator mounted on the crankshaft between the two cylinders. The engines are of modern type, fitted with double-beat drop valves to both steam and exhaust, the inlet valves on the high-pressure side being

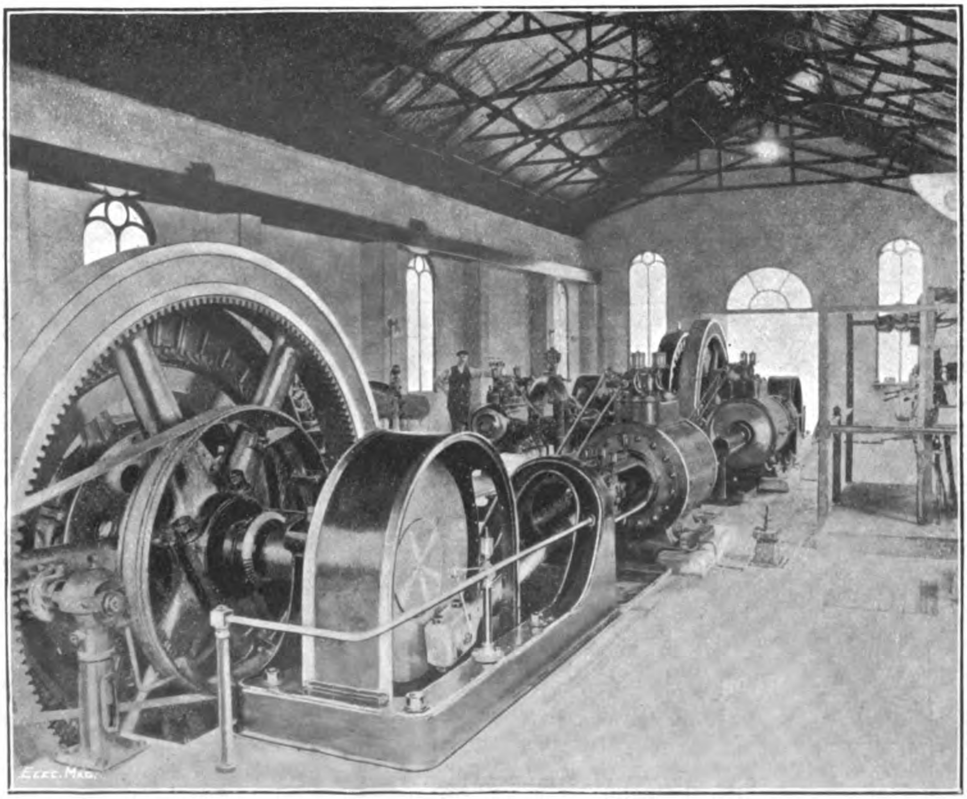


FIG. 13. MARSHALL-WESTINGHOUSE ALTERNATE-CURRENT ELECTRIC GENERATING SETS.

automatically controlled by a powerful governor. The lubricating arrangements are arranged for long runs, and the engines are made extra strong in all their parts to allow of sudden variations and changes of load, as the current supplied is used for haulage work. Each set is capable of giving off 325b.h.p., with 125lb. working pressure, and is constructed strong enough for 150lb., if at any time the boiler pressure should be increased.

These engines are also made in standard sizes large enough to give off up to 750h.p. non-condensing and 950h.p. condensing, and even larger than this when coupled tandems are used. This latter arrangement makes for very even turning moment, and enables a maximum power to be got in very little increase of space beyond that of a coupled engine.

The illustration Fig. 14 shows the main electric generating station at the Sneyd Colliery, Burslem. Each of the two dynamo sets consists of a 500b.h.p. as made by Messrs. James Howden & Co., Glasgow, direct-coupled to a standard three-phase alternate-current generator of the General Electric Company's manufacture.

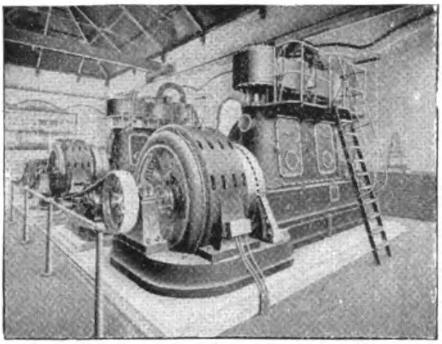


FIG 14. HOWDEN-GENERAL ELECTRIC ALTERNATE-CURRENT GENERATING SETS.

The engines are of Messrs. Howden's three-cylinder compound type, fitted with forced lubrication, and operating at a normal speed of 375r.p.m. They are in all respects Messrs. Howden's standard type, of which a large number have been supplied for various electric power installations in this country and abroad. They are provided with large bearing surfaces throughout, and are made in every way suitable for continuous running with the minimum of attention. Particular features of these engines are the

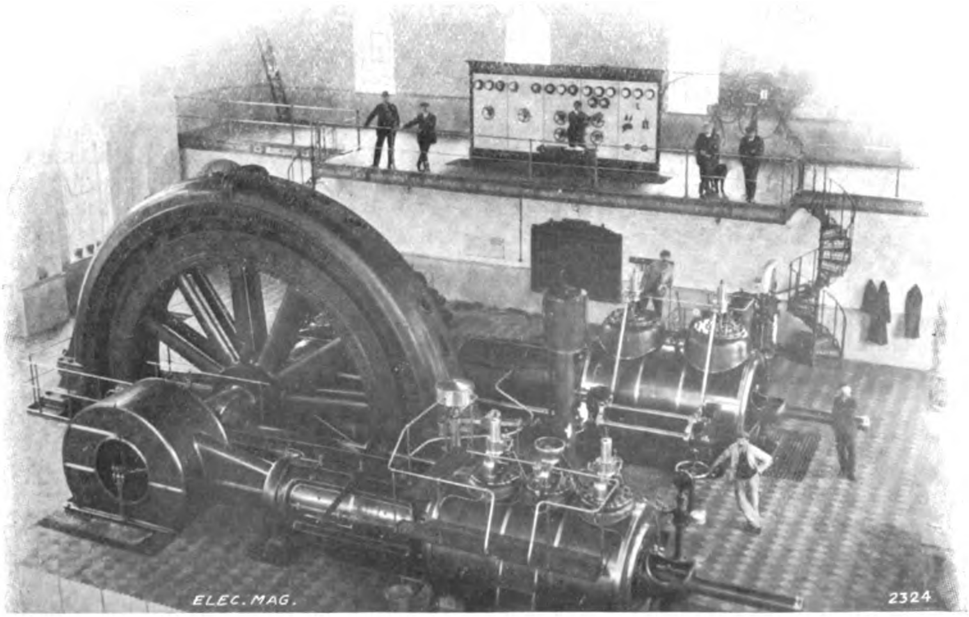


FIG. 15. A STEAM-DRIVEN LAHMEYER ALTERNATOR AS INSTALLED IN A SOUTH WALES COLLIERY.

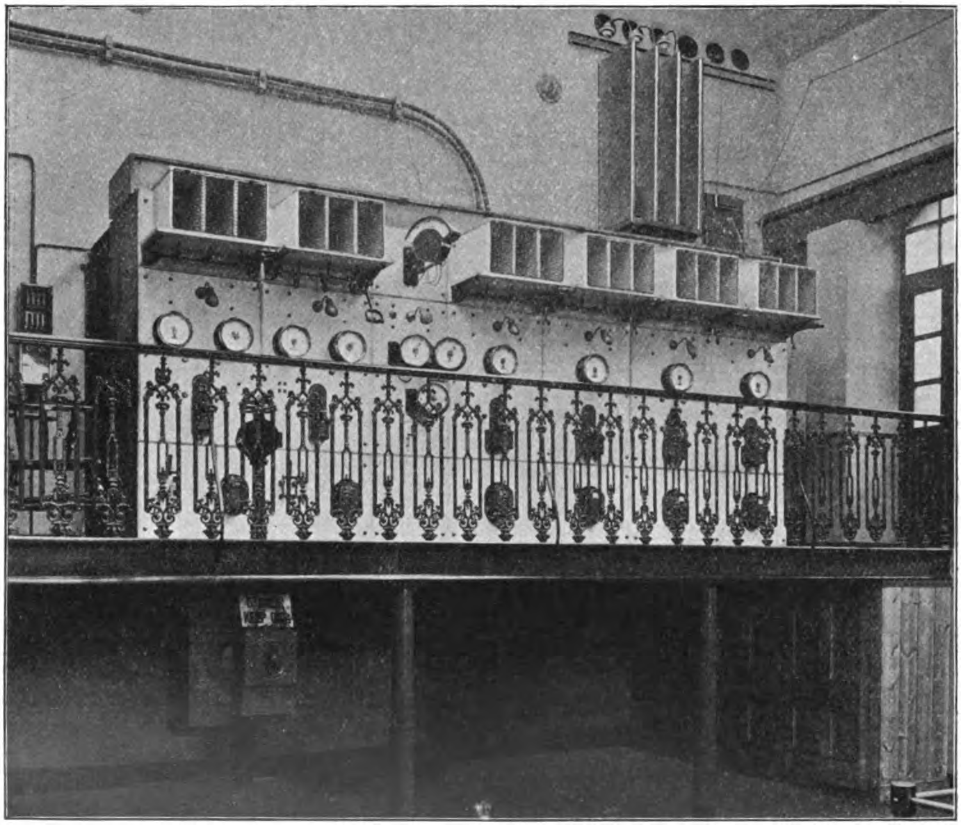


FIG. 16. WESTINGHOUSE THREE-PHASE HIGH-TENSION MAIN SWITCHBOARD, POWELL DUFFRYN COLLIERIES.

patent system of forced lubrication employed and their close regulation. The governor is carried direct on the crank shaft, and actuates a double-beat throttle valve: a regulating gear is provided which permits of a 10 per cent. variation in speed being effected whilst the engine is running. Being fitted with a flywheel, perfectly balanced throughout, and having sensitive regulation, the Howden engine has proved entirely successful for the operation of alternators in parallel.

The Sneyd colliery sets illustrated are very economical and efficient, although the steam pressure for which they have been arranged is only 85lb. per square inch.

A typical power plant as installed at a large colliery in South Wales is also shown. It consists of a large, flywheel type, three-phase alternator, direct-coupled to a horizontal compound engine.

The peculiar features of a colliery power-generating plant, as compared with an ordinary central station, are those introduced by the Home Office Rules, and these are mainly confined to details. such as relate to the spacing of generating sets, switchboard arrangements, &c. Thus no less space than 3ft. between generator and wall, and 4ft. between adjacent generators, is permissible.

Main Switchboards.

Regarding switchboard details there are many noteworthy regulations to be observed. The following are abstracts from the text of the Rules applying thereto:—

The main switchboard shall be separated from the engine room by a hard-wood rail not less than 3ft. from the front of the board. The space in front of the board shall be a platform raised not less than 6in. above the floor level.

If there are any connections at the back of the switchboard, there shall be a clear space

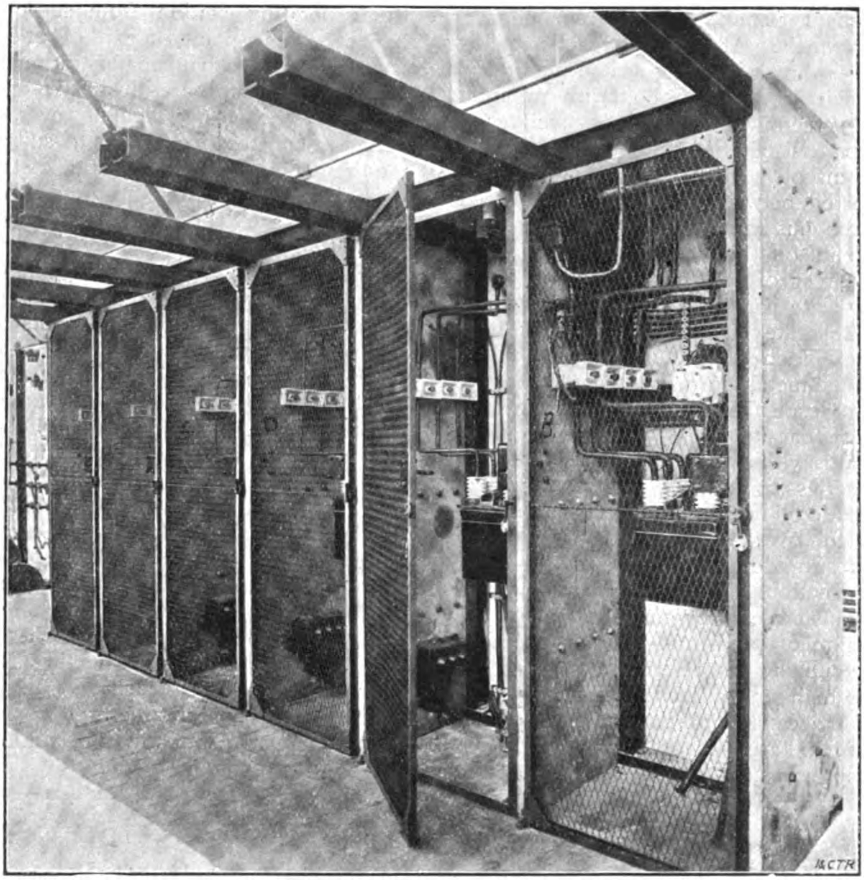


Fig. 17. Rear View of Main Switchboard shown in Fig. 16.

behind the board of not less than 3ft. If space is required for resistance frames or other electrical apparatus behind the board, the passage way must be widened accordingly. No cable shall cross the passage way at the back of the board except below the floor or at a height of not less than 7ft. above the floor. The space at the back of the switchboards shall be accessible from each end, and, except in the case of low-pressure switchboards, must be kept locked up, but the lock must allow of the door being opened from the inside without the use of a key.

Where generators are paralleled reverse current cut-outs shall also be provided.

Where the supply is maintained continuously the switchboards shall be arranged in sections, so that all pressure can be cut off from any section for the purpose of cleaning or repairing it.

If the transmission lines from the generating station to the pit are overhead there shall be lightning arresters in connection with the feeder circuits.

A typical example of modern colliery power-house switchboard work is shown in the accompanying illustrations.

Figs. 16 and 17 show respectively the front and rear views of a main switchboard as supplied by the British Westinghouse Company, Ltd., to the Powell Duffryn Steam Coal Company, South Wales, for surface use This switchboard is for the control of two 1000 k.v.a. 3000-volt three-phase generators, and four outgoing feeders, which supply energy to various pits; and is of such design as to ensure safety to the operator, and to permit of repairs being carried out on any portion while the remainder is in operation.

The first two panels, starting from the left, control the generators, the third is an instrument panel, and the remainder are feeder panels. At the top of each panel is a 3-pole air-break isolating switch mounted on an insulating division box with expanded-metal screen; these boxes, as well as the face panels of the switchboard, being of white marble. The isolating switches are connected between each generator or feeder with the bus-bars, which run in slate compartments on the top of the board.

The rear of the switchboard is divided up by slate partitions in such a way as to form separate cubicles at the back of the panels. Each cubicle is provided with an expanded-metal door, which is interlocked with its respective isolating switch in such a manner that it cannot be opened until the apparatus within is rendered "dead."

In series with each isolating switch is an automatic oil-break switch, which is provided with an over-load release, the generator switches in addition having a reverse-current release action. These automatic switches, the transformers for the instruments and release relays, and the fuses, &c., are placed in the cubicles just referred to.

The high-tension feeders from this switchboard are carried overhead from the power station, and are consequently provided with lightning arresters and choke coils to protect the generating station from static disturbances. The point of exit of one set of feeders may be seen in the illustration, Fig. 17.

The views shown are illustrative of a high grade of switch-gear, which, however, may be varied in constructive details to suit special requirements. For main and distribution switchboards operating at pressures above 3000 volts, a class of distribution and interlocking mechanism similar to that described above is adopted by the Westinghouse Company, excepting that more liberal spacings are allowed, and the compartments containing the h.t. apparatus, instead of forming the rear of the switchboard panels, are isolated and remote from the instrument and control panels. This type of switch-gear is subject to modification in structure depending on the kilowatt capacity of the plant to be controlled. For mining switchboards not operating above 650 volts, the standard panels of the Company are adopted, excepting that all live metal, if dictated by the requirements, is at the rear of the switchboard, the main quick-break knife switches being operated by handles projecting through the marble panels. Provision is also made for isolating any section as well as arranging it as a compartment with an expanded-metal door.

Current Transmission and Distribution.

So far as the installation of cables and transmission lines on the surface is concerned, the methods adopted follow general practice. Bare overhead conductors and insulated and armoured buried cables are both in general use, the selection being according to the nature of the electric supply and local conditions.

Where the power-generating station is situated within 400 yards of the shaft the mains may proceed direct from the power-house switchboard into the mine. In other cases a main switch-house must be introduced and installed at some convenient spot near the top of the shaft. The Home Office Rule anent this reads:

> Where the generating station under the control of the owner or manager of the mine is not within 400 yards of the pit mouth, a switch-house shall be provided near the pit mouth containing switches for cutting off the supply of electricity to the mine. The house shall only be entered by duly authorised persons, and a notice to that effect shall be posted at the door, and the same regulations as to switchboards and their enclosures in generating stations shall apply thereto.

All classes of cables, provided they are ot the highest quality (and the stringent tests demanded by the Home Office Rules ensure this) are used for pit work; rubber, paper, and bitumen types have all been employed, with varying degrees of insulation thickness according to nature and pressure of current, and of various armourings and mechanical protections according to position and method of installation and local conditions.

Selection of Cables.

The choice of type of cable largely depends upon price and personal opinion, but in some cases special conditions, such as shaft condition and depth, frequency of falls, quantity and nature of the wetness of the roads, &c., demand that great care be taken to select the most suitable type. For instance, where the shaft is deep and convenience of support limited, a light-weight cable of the all-bitumen type or a "paper-leadless" (that is, a paper insulated and bitumen waterproofed) may be preferred. Where falls are frequent not only is heavy mechanical protection required, but the cable must be of a type which lends itself to easy and complete repair, inclining one to the use of those of rubber insulation or bitumen. In many cases where not only is there abundance of water encountered, but it is highly corrosive, the lead-covered paper cable would seem to have the advantage, and so on. The lead-covered cable, moreover, has the particular advantage that in itself it complies with the Rule that under certain conditions an earthed metallic shield shall surround the conductors throughout their entire length :

> Where a medium pressure supply is used . . . the wires or conductors shall be, as far as is practicable, completely enclosed in strong armouring or metal casing efficiently connected with earth, or they shall be fixed at such a distance apart or in such a manner that there shall be no danger from fire or shock.

For higher pressures than medium the earthed metallic shield for all conductors is compulsory.

For shaft-work it is customary to use cables having a double armouring of steel wires, giving tensile strength, and supporting the cable by tightly fitting wooden clamps or cleats. In this case the cable must be supported in its length clear of the side of the shaft so that it can yield to any bulky body striking it, and generally be in the best position to escape mechanical injury and the wetness of the shaft. Another method is to instal an unarmoured cable in a closely fitting wooden casing or trough over its entire length.

Joints in shaft cables as in all mine cables are made in boxes, and in this case particular precautions are to be observed so that the entire joint is free from the weight of the cable. It is usual to arrange the joint box with its length at right angles to the cable and to make the cable suspensions particularly strong and frequent at these points.

Cables in-bye usually follow the main roads of the mine so as to be under constant observation, easy of access, and yet be in the best position for immunity from falls. As a rule they are supported from the side or roof by wooden cleats or earthenware insulators where the road is bricked or of stone, and, where the roads are timbered, by means of leather thongs nailed to the props. This method is recommended by the Rules as tending to prevent fracture or damage to the cables by falls, the supports being of such a nature that they are easily torn away from their holdings when undue weight is applied. As said, all joints are made in boxes: in safe parts of the mine and where the joint is merely between lengths of similar cable the conductors may be soldered ; in other cases, that is in fiery parts of the mine and where branches are taken off the mains, the conductors are connected by massive clamps and removable links enclosed in split, cast-iron water- and gas-proof boxes, thus affording a ready means of splitting up the cable system either for testing purposes or isolating any particular section or district.

The sub-division of circuits is effected at distribution boards, and the actual connections to fixed motors or portable machines are respectively through special types of switchboards and terminal boxes, of which typical examples are illustrated and described hereafter.

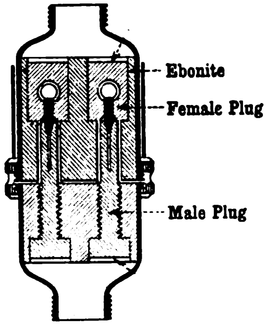


Fig. 1. Connector for Armoured Flexible Conductors.

Armoured Flexible Cables.

There is a special class of conductor to which reference should be made, viz., that which is required for coupling up portable machinery such as coal-cutters, drills, small pumps, &c. The wear-and-tear and risks of damage to these cables are obviously very great. Rubber-insulated flexible conductors with steel armouring, and often further protections of braiding, hose, or leather are generally used. The Home Office Rules demand that :—

> At points where the flexible conductors are joined to the main cables, a fixed terminal box must be provided, and be of such design that the lugs can be securely clamped without risk of undue heating, and that no live metal can be

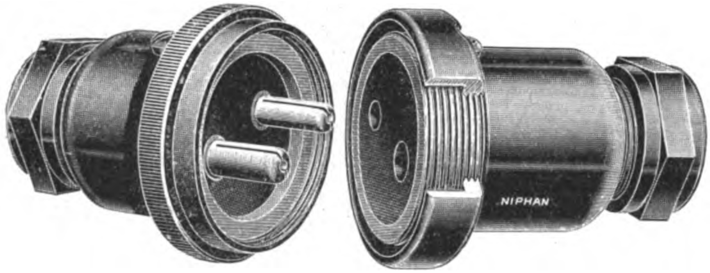


Fig. 2. Plug and Socket Water-tight Connector for Armoured Flexible Conductors.

exposed when the lid is closed. A switch shall be fixed close to or in the terminal box capable of entirely cutting off the supply from the terminal box and motor.

The great usefulness of portable armoured flexible electrical conductors for a variety of purposes, and the difficulty experienced in their successful production, has called forth considerable inventive work. One of the most noteworthy systems is that developed by Messrs. Simmonds Bros., Ltd., London, under Stokes' patents, and of which some illustrations are here given. The conductor proper consists of a large number of fine strands, 30-40 S.W.G., of specially manufactured tinned copper wire. The insulation of rubber is enclosed in a flexible steel tube which is fireproof and absolutely water-tight. It is usually made up in standard lengths of say eight to fourteen yards, and each end is fitted with a plug connector and a socket connector respectively. The design of these connectors is shown very clearly in the illustrations, Figs. 1 and 2, from which it will be seen that a perfectly good electrical connection is ensured by introducing a pin in the bottom of each socket to expand the split plug as it is forced home. The joint

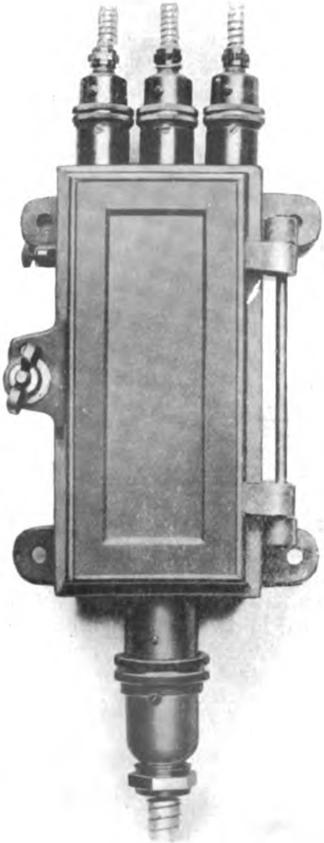


Fig. 3. Water-tight Fuse or Terminal Box for Armoured Flexible Conductors.

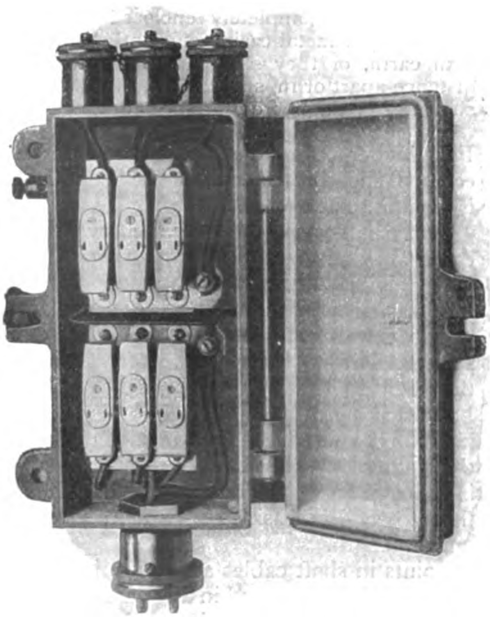


Fig. 4. Fuse Box, as in Fig. 3—Open.

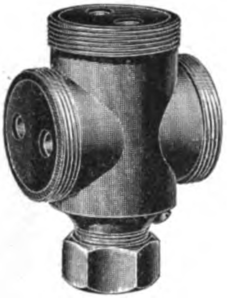


Fig. 5. T-Connector for Flexible Conductors.

is absolutely waterproof, and the metallic sheathing is continuous over the entire series of connected lengths. The construction is exceptionally massive, and suited for the roughest service, all parts are interchangeable, and the metal and insulation employed is of an entirely permanent character—the body of the connectors is turned out of brass rod, and the insulation is of ebonite. The system is one which adapts itself readily to the rapid and portable erection of any light or heavy electrical power system. The manufacturers have supplied a large quantity to the Government for military use—one of the illustrations shows a portion of an order recently shipped to India for this purpose. There would seem to be a particularly good field for this product in electric colliery work, for which it is so suitable in every way.

Wiring Work.

The underground wiring work of collieries is in many respects, and necessarily, different to standard above-ground practice. Metallic conduits are frequently used as conforming to the rules ; in other cases the wiring is simply strung on porcelain insulators, adjacent conductors being spaced not less than 2in. apart. A separate pair of leads should be run from a distributing board to each lamp or fitting. The illustrations herewith show typical examples of wiring details and fittings as best suited for mining work.

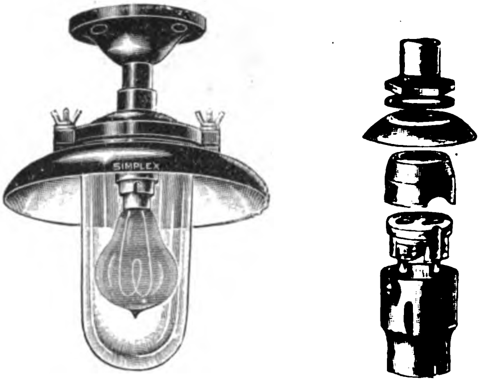


Fig. 6. Simplex Gas-tight and Waterproof Fittings.

The well-known Simplex conduit system, consisting of a combination of smooth-bore steel tubes used in conjunction with malleable cast-iron fittings and accessories, forms a most efficient and economical means of wiring. It is thoroughly adapted to suit the conditions which should be fulfilled to secure the highest degree of safety in mining work. The chief causes of wiring troubles and breakdowns are : Injury to insulation during erection ; impairment of insulation by moisture ; mechanical injury to conductors and insulation after erection. With the use of the Simplex system it is almost impossible to injure the insulation during erection and threading through of the cables, because the accuracy of manufacture of the conduits ensures a perfectly smooth interior and exterior, and also a uniform diameter, both of which are essential requirements

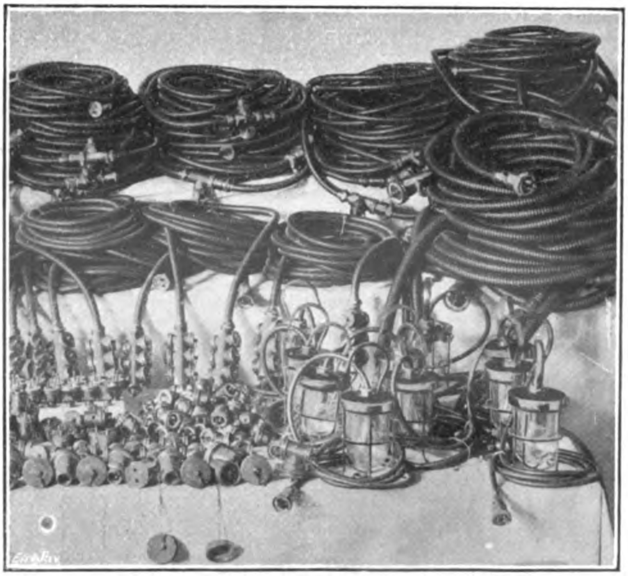


Fig. 7. Part of a Consignment of Armoured Flexible Cables and Fittings.

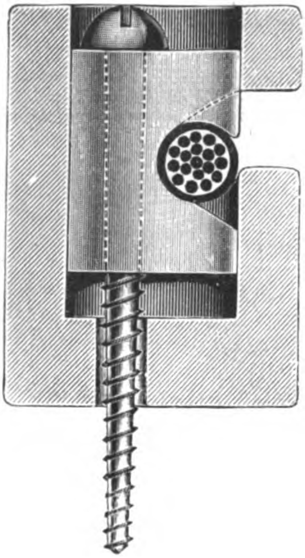


Fig. 8. Two-part Porcelain Insulator.

towards efficiency and good work. Installation wired on this system may be made perfectly water-tight by the employment of the water-tight fittings and accessories. The mechanical protection afforded the conductors is self-evident.

The Simplex water-tight lampholders, switches, light fittings, &c., are eminently suitable for colliery work. The difficulties experienced with the ordinary brass lampholders, more especially where they are subjected to the effects of moisture, have been so marked of late that the Simplex Conduits, Limited, have introduced a water-tight lampholder specially intended for all exposed work such as is general in mines.

The lampholder is of galvanised steel and can be readily wired and fixed up. It is provided with a drain cap and rubber washer which prevents any moisture from entering the fitting. A further speciality of the Simplex works is an iron-clad switchboard for light and power circuits, which is an entirely new form of board, intended for colliery work and other situations where electric circuits are exposed to risk from damage by moisture or mechanical injury.

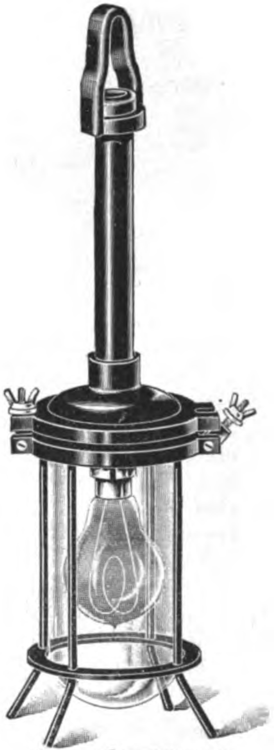


Fig. 9. Gas-tight and Waterproof Hand Lamp.

The board is built up of a series of units, and the whole is mounted on a framework of screwed solid-drawn steel conduits. Each unit consists of a separate combined iron-clad switch and fuse, and any number can be arranged for either direct or alternating

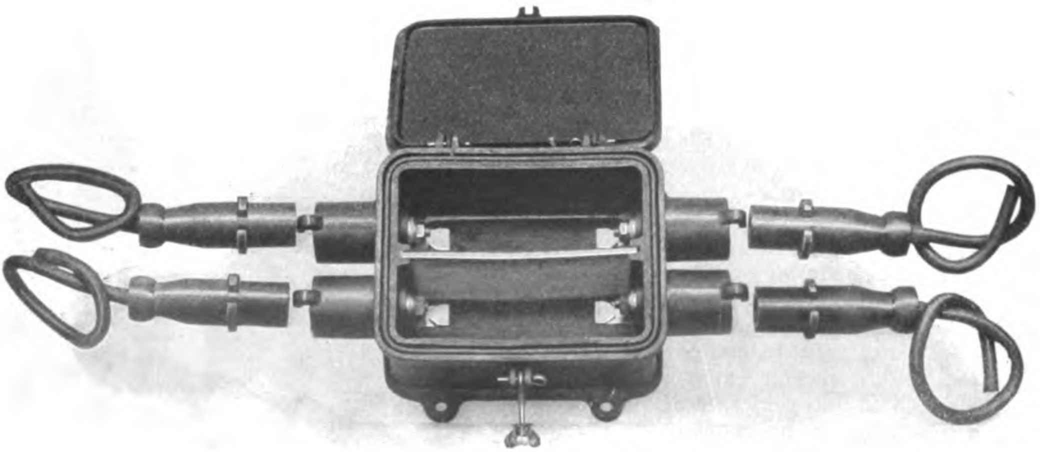


Fig. 10. Cast-Iron Enclosed Fuse Box for Mining Circuits.

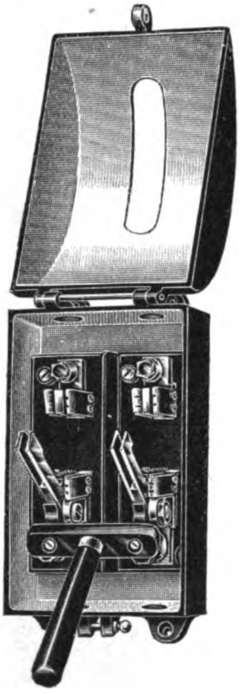


Fig. 11. Switch Enclosed in Cast-Iron Case.

current circuits. The bus bars are enclosed in an iron casing, and are entirely out of harm's way, the branch circuits between the bus bars and switches being enclosed in conduit.

Several types of detail apparatus as used for electrical circuits in mines are shown on this and the preceding page. Figs. 8 to 12 illustrate some of the specialities made by the Electrical Trades Supply, Ltd., Birmingham.

The patent two-part insulator, Fig. 8, has been extensively adopted for colliery wiring work. It consists of two circular porcelain parts, the smaller of which fits inside the lower interior of the large part, the cable is inserted in the slit, which will be noticed at the right of the illustration, and the screw, passing through both parts, binds both insulator and cable in one operation. This obviates the use of any binding wire, and also saves a considerable amount of labour.

The hand lamp shown, Fig. 9, is one of a series of strongly made gas-tight and water-proof fittings for electric lighting purposes. They are generally heavier and more substantial in their parts than ordinary water-tight fittings, and are altogether suitable for the rough usage and hard conditions of mining service.

The fuse box shown in Fig. 10 has been specially designed to meet the requirements of colliery work, and, of course, complies with the recommendations of the Electricity in Mines Commission. The case is of cast iron, of strong and substantial construction, having hinged covers with gas- and water-tight joints. The internal connections are proportioned for a very low current density, and have a standard carrying capacity of 50amp. The box is arranged for either double or triple pole circuits, and is supplied with ordinary wire fuses or replacement carriers. A large number of these boxes are in use with coal cutters, haulage motors, and electric pumps, their mobility for such purposes being much appreciated.

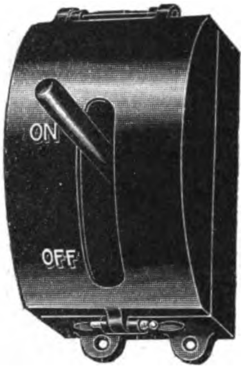


Fig. 12. Enclosed Switch as in Fig. 11—Closed.

The two illustrations, Figs. 11 and 12, are of a cast-iron-cased switch of a type which combines efficiency with durability. The switch has an exceptionally long and rapid break, the current-carrying metal being entirely independent of the handle and

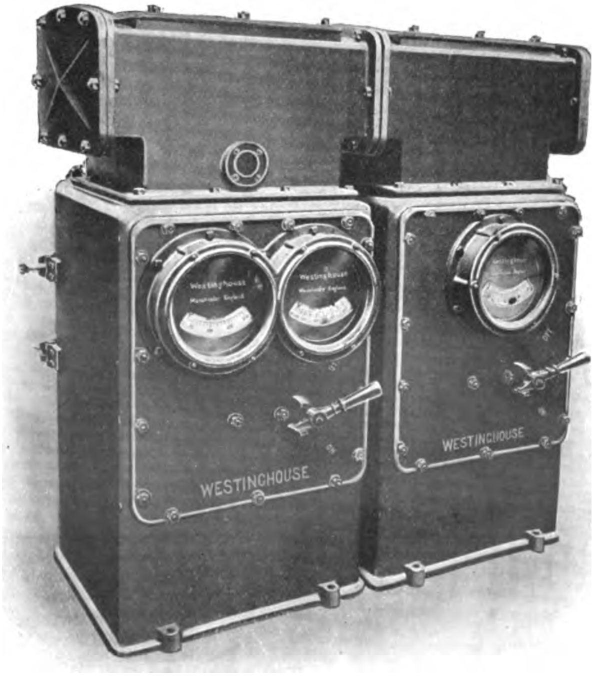


Fig. 13. Westinghouse Pillar-Type Switchboard for Underground Service.

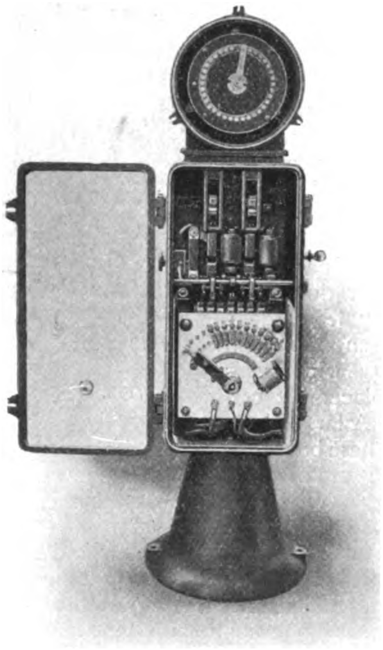


FIG. 14. MOTOR CONTROL PILLAR.

spindle. The break is ample for 500 volts, and the current density proportions are calculated on generous lines, complying with the most exacting requirements.

Underground Switch-Gear.

Naturally the switchboard requirements underground depend upon the extent of the electrical system and the size and number of the motor units employed. They form a most important part of an installation, and no effort or expense should be spared towards securing the very best, having particularly in mind the feature of liberality of design conducing to strong and reliable moving parts and certainty of operation. When it is considered that these essential features have to be combined in many cases with a gas-proof and water-tight construction, it will be realised that the problems of design are not simple, and that much judgment is necessary when making a selection. The examples illustrated may be taken as representative of the best practice, and will form a basis from which to make comparison.

For sub-station work underground the switchboards often assume large proportions, and in general arrangement follow closely the principles adopted for main central station boards. For instance, the Westinghouse underground sub-station distribution boards for 3000-volt, alternate-current, three-phase circuits, in their general design and details of construction, are similar to the main generating station board already described and illustrated on pages 136 and 137. The point of difference is that the underground board is rendered dust-proof and risks of fire are eliminated by using enclosed oil-immersed switches. Further the compartment doors at the rear of these panels are made of solid sheet metal, the same being interlocked, as in the case of the main board, with the isolating switches.

The pillar type of switchboard, as shown in Fig. 13, also of Westinghouse manufacture, has been developed to withstand rough usage and for installing in localities where the construction of specially protected switch-rooms is not feasible. In these designs radical departures from standard types have been found advisable, and oil break circuit-breakers have been adopted for opening all circuits of whatever voltage where the capacity of power to be dealt with exceeds certain limits. In the case of circuits of small capacities, air-break switches and fuses are used. These are contained in gas-tight cases, and the fuses are of an enclosed type such that on the blowing of the fuse the molten metal is not in immediate contact with the air, and therefore cannot cause a sudden expansion of gas or give rise to danger inside the fuse chamber. These underground boards are totally enclosed and of an iron-clad construction, the

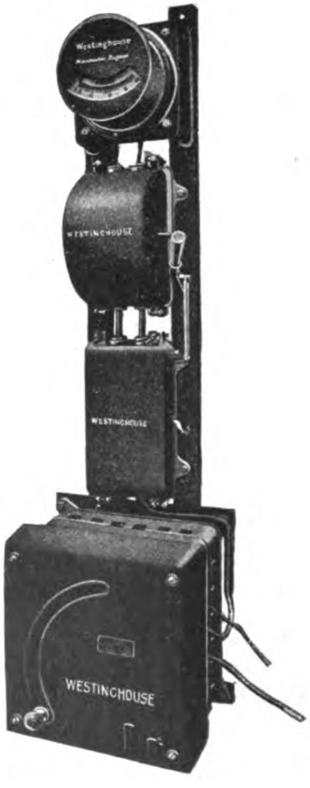


FIG. 15.

apparatus, switchgear, multi-way junction boxes, &c., being enclosed in compact, self-contained, dust-proof, cast-iron chambers, designed so that an inspection of the interior may be readily made when desired. The bus bars are contained in a separate chamber carried on and supported by the switch chambers mentioned above. The construction followed is on a unit system, and is such that extensions may readily be made to an existing board, or any unit of an existing board may be removed if necessary without interfering with the operation of the remaining portion of the board. Interlocks may be conveniently fitted so that the doors of the chambers cannot be opened unless the main switch is in the "off" position; then on the removal of plugs from the bus bar chambers all apparatus contained in any one unit is rendered dead. The space occupied by these boards is small, this being advantageous to their adoption for underground work, large cuttings in the mine for the installation of bulky apparatus being avoided. The general construction of this system meets in a very satisfactory degree mining conditions as to portability, atmospheric and fire-damp risks, durability, convenience of operation, and minimum risk of failure.

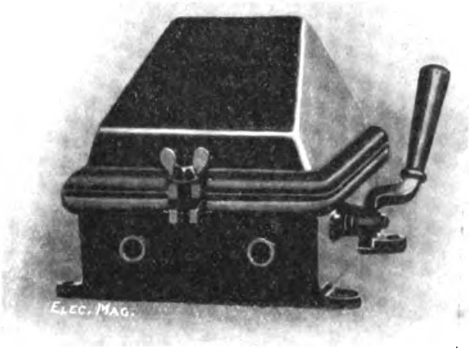


Fig. 17. The McGeoch Switch—Closed.

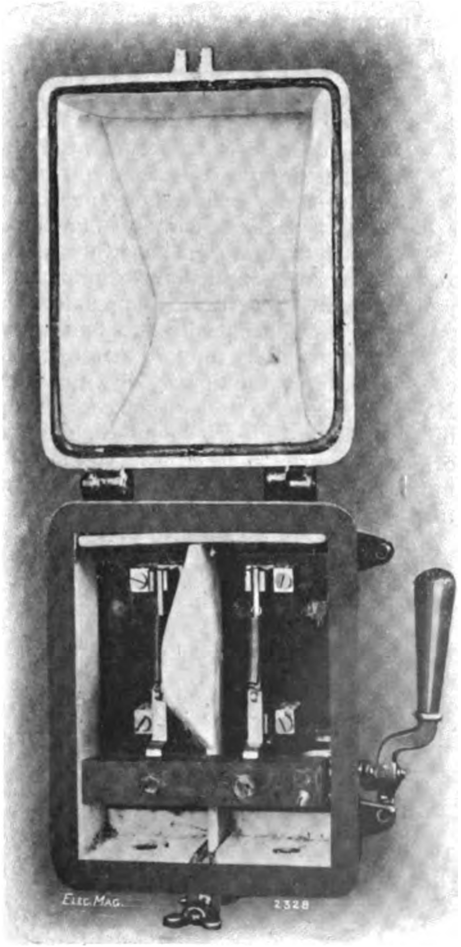


Fig. 16. The McGeoch Switch—Open.

These remarks cover only a few types of Westinghouse colliery boards, but the examples given show that the boards are designed with special reference to the following requirements: Fireproof construction; freedom from fire-damp risks; safety to operator; portability; unit system of construction, facilitating extensions, replacement, or repairs; access to interior impossible while main switch is on; any unit may be rendered "dead" without interrupting the supply to the others.

The Westinghouse Company have also developed a line of auxiliary switch apparatus for mining work, such as motor-control pillars, switch-boxes, and other details of which the several illustrations are representative. Fig. 14 shows a direct-current motor-control pillar, and Fig. 15 is an example of the Westinghouse unit-type motor-control gear, also for direct-current motors.

Figs. 16 and 17 show a special mining type of switch recently introduced by Messrs. William McGeoch & Co., Ltd. As will be seen, it is perfectly gas- and water-tight, and has the advantage of long break. It is not

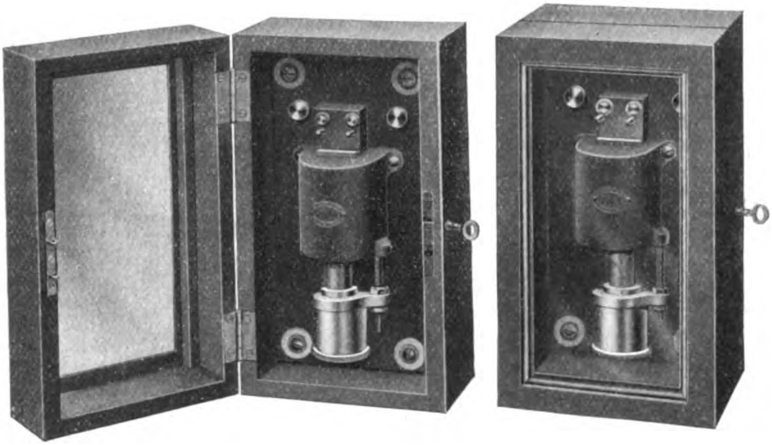


Fig. 18. The Statter Time lag for the Protection of Motor Circuits.

only double-pole, but is double-break also, and is apparently of a strong and ample character.

The Switchgear Company, Ltd., of Birmingham, under which title the old-established business of J. G. Statter & Co. is now carried on, is making great efforts to lead electrical engineers and colliery proprietors to adopt proper forms of electrical-control gear for power work. They have given particular attention to the subject of colliery switch-gear, believing that whilst the electrical equipment of a colliery reaches a higher standard of engineering in its dynamos and motors, it generally falls off woefully in its control appliances; attention to the latter is most essential to success and economy, and it is to their perfection that the Switchgear Company devotes itself. Mr. Statter, who is a director of the Company, makes a point of inviting electric power users to state exactly the objects of any electrical drive in question and the conditions of working; his Company will then design a proper scheme of switch-gear and cable work.

It is well known that the load on a coal cutter varies within wide limits: at times the load may be more than double that which the motor will carry continuously. This will not necessarily injure the windings of the motor—it all depends upon the time for which it persists. The coils on a motor are only injured when the temperature rises to a sufficient height to char the insulation. This depends upon two factors—current and time. The heat produced in the coils is proportional to the square of the current and directly to time. The heat radiated and got rid of by conduction is approximately proportional to the rise in temperature and to the time. Consequently the temperature rises approximately proportionately to the excess current multiplied by the time. Now if we have to deal with excess currents of 100 per cent., it is evident that no form of excess-current device will protect the motor; for if we assume that the motor will take 20 per cent. overload for one hour,

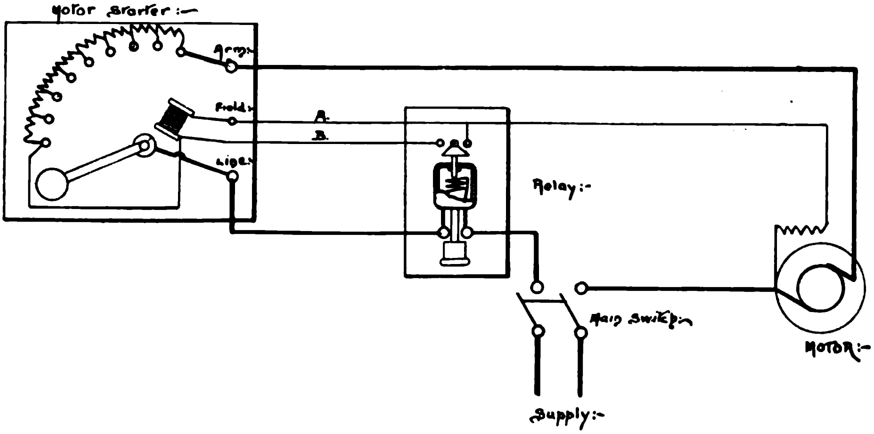


Fig. 19. Diagram of Time-lag Connections in Motor Circuit

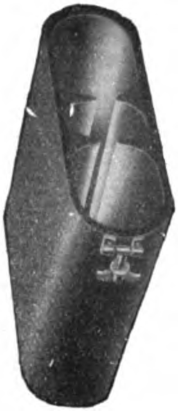


FIG. 20.

then theoretically it can only take 100 per cent. for twelve minutes. Practically, although the motor may take 20 per cent. overload for one hour it will probably break down in less than twelve minutes with 100 per cent.; because, whereas in the former case the heat has time to travel to the frame of the machine and to radiate from the machine as a whole, in the latter case it has not time, and is to a large extent dependent upon the radiation from the coils only to get rid of the rise of temperature. It can only in practice be safely trusted with 100 per cent. overload for a very short period. It will therefore be seen that what is required to protect such a motor efficiently is some appliance which will give a delay that corresponds to integrating the excess current and the time it lasts. The Switchgear Company have devised a very useful form of Statter's patent time-lag which meets this requirement. It is in the form of a relay, and is attachable to any ordinary motor-starter in the case of a d.c. motor, and to an oil-switch trip-coil in the case of an a.c. motor.

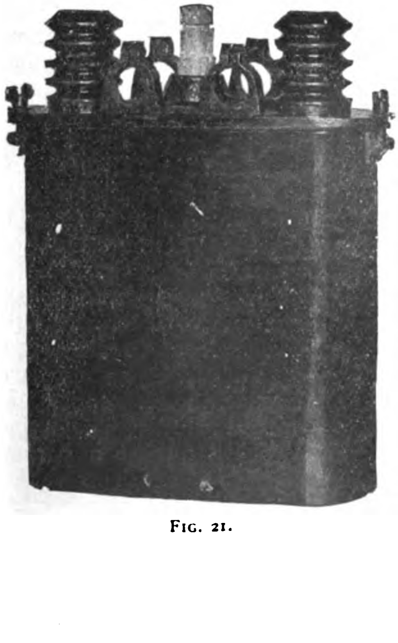


FIG. 21.

Fig. 18 illustrates a d.c. protective relay, and Fig. 19 shows the necessary connections. No mechanical connections are necessary; any competent wireman can connect the apparatus and put it to work.

A motor protected with this device is safe under all conditions of overload, but it will not be prevented from working at 100 per cent. overload for short spurts.

The wood-cut shows the relay in a wooden lock-up box with glass front; for underground work a lock-up cast-iron case is used.

It is to be noted that when the motor has been cut off the circuit after a heavy and persistent overload, the device re-sets itself so that the operator has only to wait one minute and he can start again and let the cutter clear itself, if it can; if not, the relay will again act, and the cutter should then be cleared before switching on again.

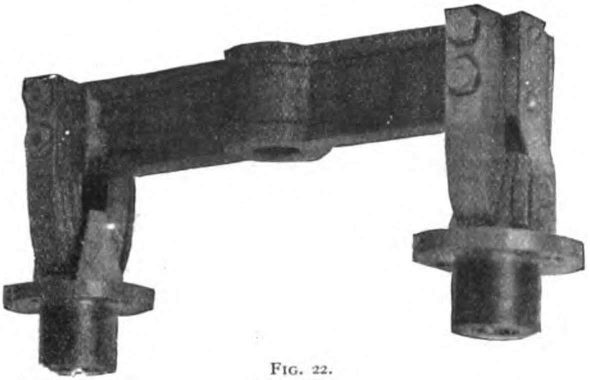


FIG. 22.

Figs. 20, 21 and 22 illustrate the Switchgear Company's unit system of building up oil switches. Fig. 23 shows an automatic oil-switch with tanks in place; the automatic feature is arranged to be controlled by the protective relay above referred to.

The unit system enables the switches to be built up for double, triple, or four-pole, as may be required, and it will be noted that each pole is provided with a separate tank. This sub-division of the tank has two advantages; in the first place it gives a much better insulation, and in the second place each tank becomes a handy article which can be readily removed by one man. The tanks themselves are made of moulded indurated fibre. The fibre, after being moulded and pressed into the desired shape, is treated by a special process which gives to it insulating properties substantially equal to porcelain. Tanks for ordinary voltages have

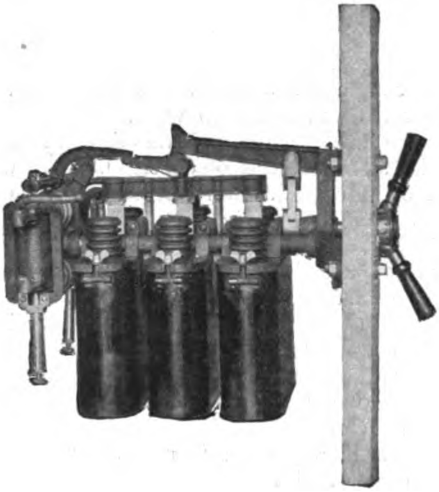


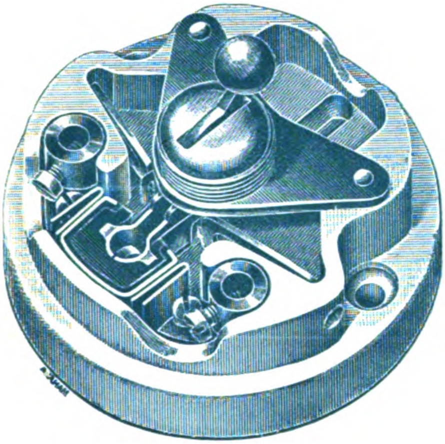
FIG. 23. THREE-PHASE AUTOMATIC OIL-TYPE SWITCH WITH STATTER TIME-LAG ATTACHMENT.

no projecting fins as shown in Fig. 20. The shape of tank illustrated is for high potentials, and it will be seen that since the wooden switch-rod lies in the centre cell a complete barrier is formed between the arcing points in the switch unit. The contact blocks, as shown in Fig. 22, are made with laminated brushes bedded on to wedge-shaped contacts, after the manner of the laminated brush direct-current circuit-breakers. A sparking piece or "flicker" is arranged to take the arcing on the side of the wedge so that the surfaces which make contact with the laminated brushes are always clean, and no sparking takes place thereon.

The firm of A. Reyrolle & Co., Ltd., of Hebburn-on-Tyne, make a distinct speciality of the manufacture of electrical switch appliances for mining work. Of these attention may be directed to one or two of the most typical. The Reyrolle three-pole oil-break switch is mounted on a framework consisting of one casting designed to shield the switch and to enclose the porcelain terminal block. The switch itself is perfectly watertight, and is quick-break, a double break being provided on each pole, and the six contacts are mounted on a stout asbestron cylinder. The moving contacts consist simply of three solid copper blocks embedded firmly in a triangular asbestron carrier revolving with the operating spindle. The break occurs simultaneously on all three poles, and in opening the switch a solid body of oil is put in motion and forced past the contacts, thus promply extinguishing any arc. The parts are few and are all interchangeable, being machined to gauge. The oil receptacle can be removed at any time without loosening any of the connections or interfering with the mechanism of the switch. The terminals have been specially designed to facilitate wiring, and the framework of the switch is designed for an earth connection. The switch handle is insulated and has a definite "off" and "on" position.

The illustration Fig. 24 shows a mining type of motor-starter panel of Messrs. Reyrolle's make. The panel consists of a slate base mounted upon an enclosed iron framework. Doors are provided at the sides of this frame, but these can be locked so that the parts in the inside are only accessible to those who have the necessary authority and the key for opening the padlock. The panels are made of various capacities, and they contain three-phase oil-break switches, which are either hand operated only or are provided with an overload automatic release in addition to the hand-operating device. A pilot lamp is mounted at the top of the board over the ammeter. The pilot lamp is provided to indicate the potential on the panel and to show when the connections are alive. The potential transformers are protected by dust fuses enclosed in the porcelain boxes fixed directly over the switch. Those acquainted with the circumstances of colliery working will appreciate the advantages offered by the foregoing arrangement.

The Reyrolle drum-type starter contains all that is required for the manipulation and protection of a motor circuit. It contains: d.p. switch, overload and no-voltage coil, fuses and resistance. This resistance is of a block type and is so constructed that the motor can be started at all loads whilst the handle is held on the first stud. This starter protects the motor against every possible contingency; at the same time the method of operation is so simple as to be readily understood by the most unskilled operator. The use of a special form of resistance is a unique feature of these starters. The resistance acts as an automatic electric valve, the resistance of which gradually decreases until it allows just so much current to pass through as is required for starting the motor. This action is obtained quite automatically while the handle is held on the first stud. This



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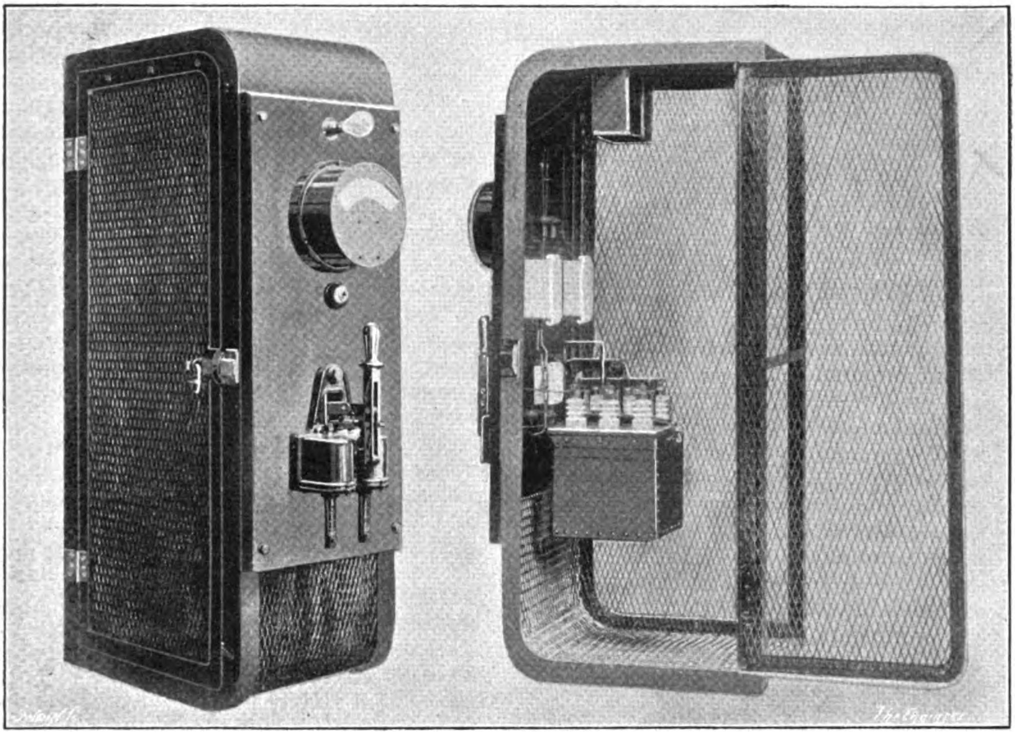


FIG. 24. REYROLLE TYPE OF MOTOR-STARTING PANEL FOR MINES.

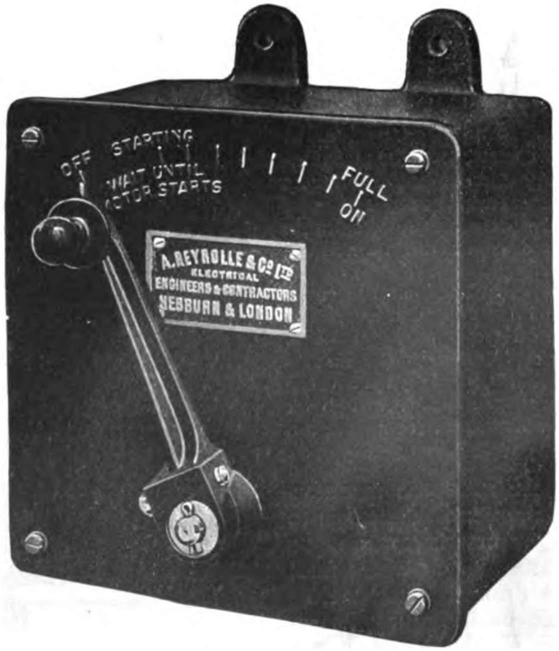


FIG. 25. TOTALLY ENCLOSED MOTOR-STARTER.

characteristic is due to the design of the resistance and to the method of construction; it is entirely independent of any mechanical movement. The resistance can stand large overloads and can even be occasionally worked till it is red hot without serious risks. When complete it presents the appearance of a solid block of metal, which can withstand any amount of rough usage. The resistance parts do not oxidize or otherwise deteriorate. The motor can be started against full load. Sparking on the contacts is avoided, because while the handle is held on the first contact stud the motor starts and the back e.m.f. of the motor increases, and the pressure across the remaining studs of the starter is automatically reduced with the resistance. A totally enclosed form of motor starter fitted with the special form of resistance is shown in Fig. 25.

Insulation Tests and Records.

What may perhaps be classed as a detail of the transmission and distribution part of electrical colliery work is the condition of insulation of the entire system, a feature of vital importance and which in consequence is covered by binding regulations. The article hereafter by Mr. A. F. Harris covers the subject thoroughly in all its points.

Leakage Indicators.

A. F. HARRIS, A.M.I.E.E., Associate of the Central Technical College.

Having in view the serious consequences which may result from faults either due to defective material or faulty workmanship, or from the ordinary deterioration with time, it becomes very necessary to provide reliable apparatus which will at once give an indication of the condition of the insulation of the whole electrical system.

The Commission appointed in October, 1902, by the Secretary of State for the Home Department reported as to what precautions were considered necessary in order that such risks should be reduced to a minimum. As a result of the recommendations of this Commission the Home Office issued, amongst others, the following rules :—

> The insulation of every complete circuit other than telephone or signal wires used for the supply of energy, including all machinery, apparatus, and devices forming part of, or in connection with, such circuit, shall be so maintained that the leakage current shall, so far as is reasonably practicable, not exceed 1/1000 of the maximum supply current, and suitable means shall be provided for the immediate localisation of leakage.
>
> In every completely insulated circuit earth or fault-detectors shall be kept connected up in every generating and transforming station, to show immediately any defect in the insulation of the system. The readings of these instruments shall be recorded daily in a book kept at the generating or transforming station or switch-house.

As a result of these rules the manufacturers of electrical instruments at once set to work to place upon the market instruments called leakage indicators, which would fulfil these requirements. Prior to this time, in the majority of cases, no indicating instruments were used at all; and the only knowledge of the condition of the insulation of the system was obtained by periodical tests carried out by means of ordinary insulation testing sets.

In some cases, generally at the request of the consulting engineer, an indicating instrument was supplied, but at that time the only ones available were more or less inaccurate, so that they were misleading, and often worse than useless, since they sometimes indicated a high value for the insulation resistance when in reality it was very low indeed. Amongst this class of apparatus may be placed the electrostatic ground detector, a voltmeter calibrated in terms of resistance at a given voltage, and an ammeter placed in the earth circuit.

The electrostatic ground detector was, the writer believes, first used in the United States, and is suitable both for direct-current and also for alternating-current work. It possesses the advantage of being adaptable for use on high-tension circuits by introducing extra capacity in series with it in the shape of highly-insulated condensers. This apparatus, although some considerable numbers have been used, is of very little value, as it simply indicates the difference of the insulation resistance between the two mains, the actual values being purely relative, and it is quite impossible to ascribe to the indications any real meaning.

Fig. 1 illustrates such an arrangement for direct-current or single-phase alternating current.

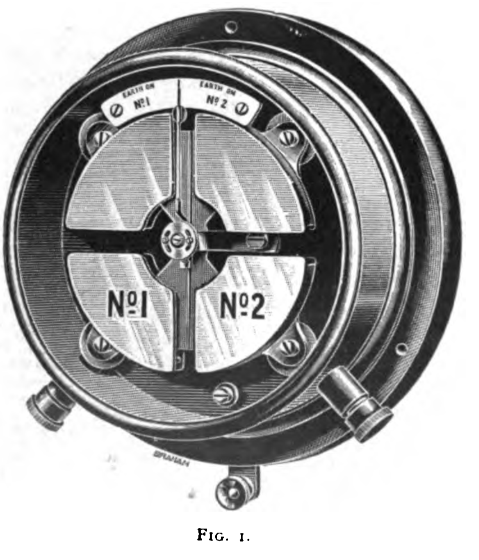


Fig. 1.

The quadrant marked No. 1 is connected to one main, and the quadrant marked No. 2 to the other main. The needle is connected to earth. Then, provided that the insulation of the two mains is good, the pointer remains in the centre position of the scale, indicating good insulation. Directly the insulation of one of the mains becomes impaired the distribution of potential alters, and the quadrant connected to the faulty main more nearly approaches the potential of the earth, with the result that the needle is attracted into the opposite quadrant, indicating thereby that the insulation of one main is defective. The magnitude of the deflection may be taken as an approximate guide to the condition of affairs, but, as previously pointed out, the indications have no absolute value.

The use of a voltmeter calibrated in terms of resistance at a given voltage is also open to serious objections.

The general arrangement is shown in the accompanying diagram (Fig. 2). When it was desired to find the insulation of the positive main, the instrument was joined to the negative main and to earth, and the indication was taken to have some connection with the value of the insulation, the operation being reversed to test the insulation of the negative main. In practice the instrument was provided with a two-way switch, so that it could be successively connected to either main. Under either circumstances the instrument (which must necessarily be of high resistance) is always shunted by the fault on the other main, and, as a "fault" of some value or other always exists, the indications are always inaccurate. Under some circumstances the indications may be of value, but they are never really reliable, and sometimes dangerous, as they always indicate a better condition of affairs than actually exists.

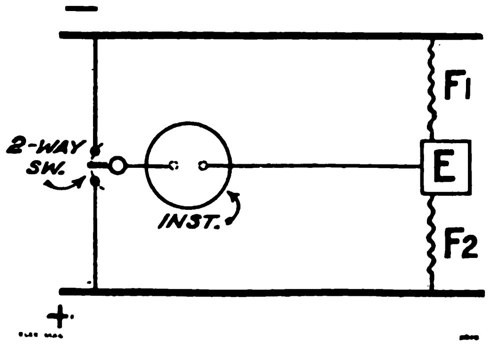


FIG. 2.

In the case of an ammeter placed in the earth circuit the indications are sometimes of use, but, again, they may be seriously misleading. Take the case of a three-phase alternating-current system with the neutral earthed at the station; an ammeter is connected in series with the earth. In practice the ammeter is generally protected by a short-circuiting switch, so that, in the event of a bad earth, the large current does not pass through the ammeter, and thereby damage it or burn it out. The only circumstances under which the indications of the instrument can be accurate are those of a fault on one main when the other two remain perfect, which is a condition never attained in practice. Owing to the phase difference between the different leakage currents, the indications are always below what they should be; in fact, if the three mains had approximately equal insulation resistances, although they might be low, the ammeter would read zero. Another objection to the employment of an ordinary alternate-current ammeter is that it is, of course, affected by capacity currents, as well as by the leakage currents. It is not the intention of the writer to discuss the effect of these capacity currents on alternating-current leakage apparatus; but these currents being wattless, by the employment of a suitable form of instrument, they can be eliminated from its readings.

From the foregoing it will be noticed that the various instruments described are all open to various objections. Immediately on the publication of the Home Office Rules, however, the leading firms of electrical instrument makers devised apparatus which would conform as nearly as possible to the new requirements.

The apparatus manufactured by the various firms differs very little, and for direct-current circuits with both mains insulated consists of a moving-coil instrument arranged with a centre zero, so that the pointer is free to deflect in either direction. Such an instrument is shown in Fig. 3. The method of its use is as follows:—

A high resistance of, say, 100,000 ohm is connected across the mains, and the centre-point of this resistance is put to earth through the moving-coil instrument. Under these conditions the instrument is always

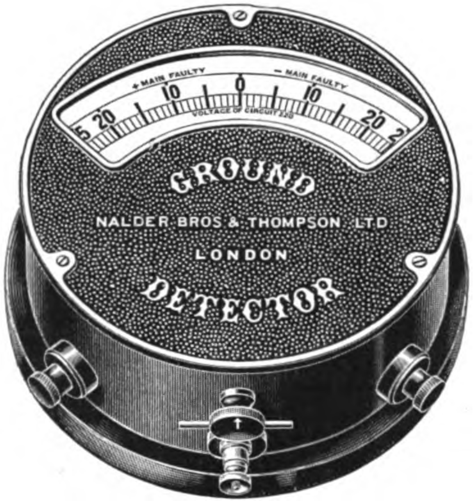


FIG. 3.

indicating which main is in the better condition, and if the insulation in one main suddenly breaks down, or shows signs of deterioration, the pointer will deflect, indicating that there is a fault on this main.

The instrument is also provided with a two-way switch, by which it can be connected to either main and to earth with a known resistance in series and the deflection noted in each case.

From these two observations the actual insulation resistance of both mains and the current to earth can be calculated. Referring to the diagram (Fig. 4), + and − represent the two mains, E is the e.m.f. between them, x and y respectively the insulation resistance of the mains + and − to earth, and r the internal resistance of the moving-coil instrument. On connecting the instrument to the main +, a deflection θ is obtained, and, when connected to main −, a deflection ϕ. The insulation resistances x and y can be obtained from the following equations:—

$$x = \frac{r}{\phi}\left\{ \mathrm{E} - (\phi+\theta) \right\}$$

$$y = \frac{r}{\theta}\left\{ \mathrm{E} - (\theta+\phi) \right\}$$

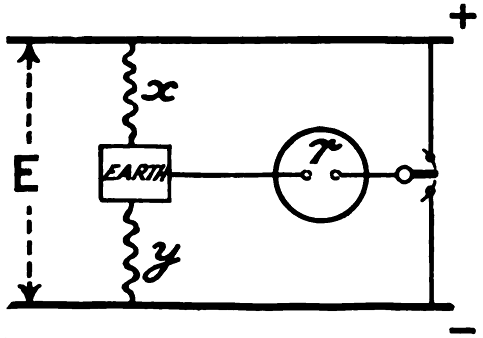


FIG. 4.

The instrument is so constructed that when the moving coil is switched on to the mains + and −, the instrument is temporarily disconnected from the high resistance which is put across the mains.

In actual practice, instead of having to solve the equation every time an observation is taken, a table of values is supplied with each instrument similar to the one shown in the illustration, Fig. 5, from which the insulation resistance and earth current are read off directly, so that the whole measurement is reduced to one of extreme simplicity.

It is quite easy to arrange this instrument so that when the earth current exceeds the limit allowed by the Home Office Rules, a bell is caused to ring in the station, thereby calling attention to the fact that an earth has occurred.

In connection with alternating-current circuits, whether single, two, or three phase, the only arrangement that the writer has found really satisfactory is one which was originally suggested by Mr. Raphael in his book on "Localisation of Faults." This has been brought into practical form and placed on the market by Messrs. Nalder Brothers & Thompson, Ltd., of London.

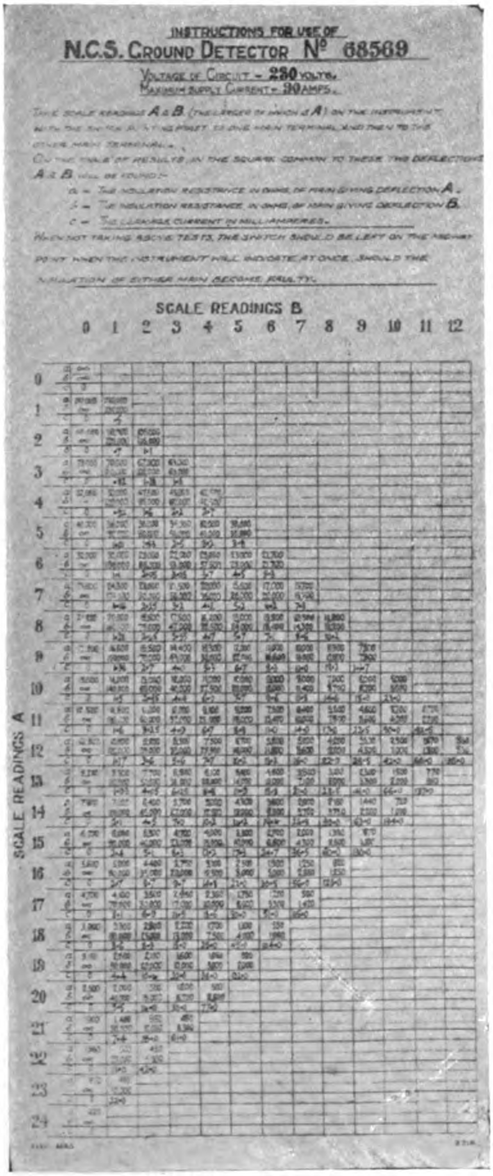
The principle made use of in this apparatus is that of superimposing a small continuous current on the alternating-current system. This continuous current is measured by means of a permanent-magnet moving-coil instrument, which is, as is well known, unaffected by alternating currents.

The source of direct current may either be a battery, a small generator, or the exciter of an alternating-current generator.

The moving coil instrument is calibrated with the known voltage of the battery or generator, and the scale reads directly in ohms, thus giving the insulation resistance of the system and earth, and also the leakage current in amperes.

It will be readily seen on referring to the diagrams Figs. 6 and 7 that the actual leakage current can never be greater than the indicated current. This is a very important point, and is not the case with any of the other forms of alternating-current leakage indicator.

If the insulation resistance of the system falls below the Home Office requirements a fuse blows, and the blowing of this fuse closes a local circuit, which keeps a bell ringing until the fault is corrected.



INSTRUCTIONS FOR USE OF

N.C.S. GROUND DETECTOR Nº 68569

VOLTAGE OF CIRCUIT – 230 VOLTS.
MAXIMUM SUPPLY CURRENT – 30 AMPS.

Take scale readings A & B (the larger of which is A) on the instrument with the switch pointing first to one main terminal and then to the other main terminal.

On the table of results, in the square common to these the deflections A & B will be found:—

a = The insulation resistance in ohms of main giving deflection A.
b = The insulation resistance in ohms of main giving deflection B.
c = The leakage current in milliamperes.

When not taking above tests, the switch should be left on the middle point when the instrument will indicate at once should the insulation of either main become faulty.

SCALE READINGS B

0 1 2 3 4 5 6 7 8 9 10 11 12

SCALE READINGS A

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

FIG. 5.

Fig. 6 shows the general arrangement of this apparatus for a completely insulated three-phase circuit. A B and C are the star windings of the generator; the instrument is inserted between one phase, say at the point C, in series with a large non-inductive resistance, through the cells or exciter to earth. The object of the high inductive resistance is to prevent any alternating current flowing to earth through the moving-coil instrument. It will be noticed that when the current to earth gets too large the fuse F blows, which results in the closing of the bell circuit, and thereby calls the attention of the attendant.

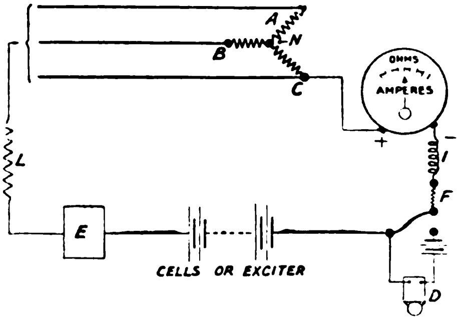


FIG. 6.

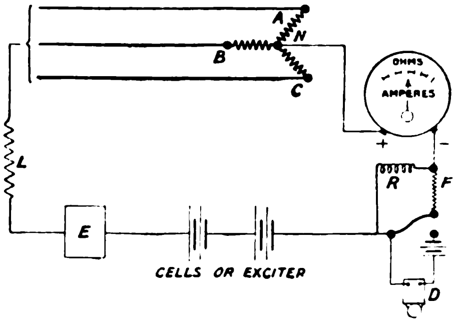


FIG. 7.

Fig. 7 shows the application of the system to a three-phase arrangement with an earthed neutral. In this case the ammeter is connected between the neutral point N and earth. To prevent the neutral wire being entirely disconnected from earth when the fuse blows the resistance R is connected in parallel with the fuse; this resistance is just large enough to prevent the current through the instrument due to the leak doing any damage. The resistance of the instrument, fuse and battery being only about 5 ohms, or if an exciter be used only about one ohm, consequently the earthing of the neutral is in no way impaired.

The advantages of the above apparatus consist in the fact that the earth current cannot possibly be greater than the value indicated on the instrument, and, secondly, that the capacity currents do not affect the indications of the instrument, nor does the fact that the leakage currents are out of phase in any way lead to erroneous results.

The instruments above described are, without exception, for switchboard use, thus they are permanently connected up to the installation, the object being that a constant indication is afforded of the condition of the insulation of the system.

When a fault has been indicated by the alarm bell of the leakage indicator the localisation of it must be made with an ordinary insulation testing set, of which the "Ohmer" made by Messrs. Nalder Brothers & Thompson, and Evershed's "Megger," are the most popular; they are used on practically all electrical power installations and are so well known that they need not be described here.

The methods employed and apparatus supplied by Messrs. Everett, Edgcumbe & Co., Ltd., for Leakage Indication, are as follows :—

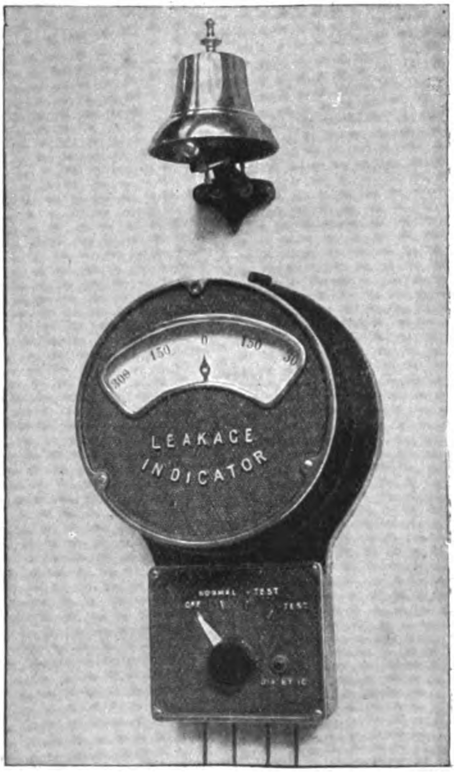


Fig. 1.

Fig. 1 shows the type of instrument employed for two-wire direct-current systems, and Fig. 2 shows diagrammatically the connections. As will be seen, the switch and terminals are entirely enclosed, so that not only are they protected from dust and damp, but no live parts whatever are exposed. When in the normal position, the instrument, which consists of a sensitive moving-coil milliampere meter, is connected to earth from the central point of a high resistance joined across the mains. This is the position in which the instrument is left continuously, and so long as the insulation of the two mains is perfect, the pointer will remain at zero in the centre of the scale. The occurrence of an earth on either main is at once shown by a deflection of the pointer towards either the stop marked "+ main faulty" or that marked "− main faulty" as the case may be. At the same time, a really bad earth causes a relay, contained in the instrument, to close the circuit of a loud-sounding bell; or, if preferred, a coloured lamp, so as to draw the attention of the attendant to the fact that something is wrong.

It will be seen at once, however, that the indications so obtained are only relative and do not allow of the direct measurement of either the leakage current or of the actual insulation of the mains. In order to enable this also to be done, two further stops are

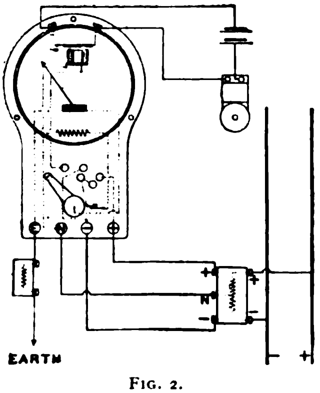


Fig. 2.

provided, by means of which the instrument can be connected between the positive and negative mains respectively and the earth. Two readings (in milliamperes) are thus obtained, and, by means of a specially calculated table, not only the leakage current, but also the insulation resistance of each main can be at once read off. It should be mentioned that the results so obtained are equally accurate no matter what may be the relative resistances of the two mains. The table is of the "ready-reckoner" type, and is perfectly easy to use.

The three-phase instrument is in general design very similar to the direct-current pattern, excepting that, in place of the two stops "+" and "–," three are provided, one for each phase, A, B, and C. The connections are shown in Fig. 3, from which it will be seen that, when in the all-day or "normal" position, the instrument is connected between an artificial neutral point and the earth. The occurrence of a fault is at once shown by a deflection of the instrument, and by testing on the A, B, and C stops, in rotation, the faulty main can be at once located. It must be remembered that the main giving the *smallest* deflection is the faulty one, while the magnitude of the readings obtained on the other two stops indicates the gravity of the fault. Unfortunately, in the case of three-phase systems, the same accuracy is not possible as is the case with the direct-current indicators. This is owing to the disturbing effects of capacity, &c. However, they comply with all the requirements of the new rules, and are duly accepted by the Home Office authorities.

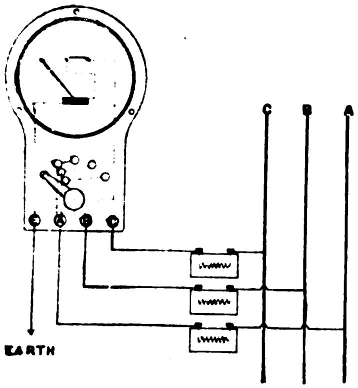


Fig. 3.

For high-tension systems it is inadvisable to connect any one of the mains directly to earth, and to obviate this a very efficient electrostatic leakage indicator has been developed by Messrs. Everett, Edgcumbe & Co. It consists, in the case of a two-wire single-phase system, of an electrostatic movement provided with a single vane connected to earth, and two fixed vanes, one connected to each of the two mains. The arrangement is thus practically a differential voltmeter showing the potential of each main relatively to that of the earth, and, as is well known, the resistance to earth is inversely proportional to this potential. The scale reads from central zero in either direction, thus showing which of the two mains is at fault.

For three-phase systems, a compact arrangement of three separate electrostatic voltmeters, one being connected between each main and the earth, is provided.

Electrical Winding.

The large powers and particularly the widely fluctuating loads attending colliery winding have necessitated special arrangements being made for the utilization of electricity for the purpose. Standard electrical appliances, as adopted for the generality of power work, including hoists and lifts and haulages, will not economically meet the requirements of pit-winding. The particular engineering problems to be solved are indicated in the following descriptions of the principal methods devised.

It is in this branch of applied electricity that the conservatism of the average British coal-master is most in evidence at the present day. The Continent can truly claim to be the home of electric winding. The pioneer work was all done there years ago, and to-day there are large numbers of plants in regular service demonstrating the economy and real success of this final conquest of electricity for all mining power. But we have at all events made a start in electrical winding in this country: there are two or three installations at work and several on order or being erected. So important is the subject and so promising in its prospects that a number of our leading electrical manufacturers are making specialities of one particular system and plant or another. Naturally those British electrical firms who are associated with the leading Continental electrical works are in the forefront, for they can indeed cite instances of work done on their methods and quote results obtained in practice. Yet, as will be seen hereafter, these cosmopolitan-when-convenient firms have not the monopoly of electric winding in this country.

As exemplifying the general principles underlying this branch of electrical work, the following abstract of the most recent "Institution" paper will be of interest. Whilst giving a general discussion on all the best-known systems Mr. Wood devotes himself in the main to the methods adopted by the Lancashire Dynamo & Motor Company, Ltd., a firm who have earned an enviable reputation for keeping abreast of the times in matters of electrical power and plant manufacture.

Some New Flywheel Storage Systems.*

A. P. WOOD.

The subject of electric winding is one which has had a considerable amount of attention during the last few years from electrical engineers. There were several papers read on this subject last year before the Institution, but they were principally on the question of electric *v.* steam winding. It is not intended to go into the merits of the two systems here, but the author believes it was agreed that electric winding could not be commercially practicable unless in cases where the value of the coal used at the pit exceeded in value 2s. 6d. to 3s. per ton. The fact remains that a considerable number of electric winders are being installed in this country at the present time, and the practical results attendant on these installations will be, of course, the best warrant as to their merit.

It is proposed to describe a few patents which have been taken out during the last year. These patents comprise both three-phase winding and continuous-current winding; the former have been taken out by Mr. McLeod and the author, and the latter by Mr. Kelsall, Mr. Warburton, and the author.

Now, what are the principal requirements of electric main winding plants?

(1) Cheap first cost; (2) low coal costs; (3) ability to run the main motor in case the flywheel storage system fails; (4) ease of control and simplicity; (5) desirability of running the winding motor at nights for lifting water, &c., without the use of the flywheel set (the winds in this case are generally about 1 per 20 minutes).

The requirements of electric winding are, of course, very severe, as was shown by a diagram, the power required during acceleration being 2000h.p. and the average demand being about 800h.p.

Three-phase Systems.

The system best known in this country and abroad is the Ilgner, but this is not a true three-phase system, as it is necessary to convert to continuous current, using continuous-current motors on the main winding gear. It consists, briefly, of a flywheel system, including a three-phase induction motor coupled to a continuous-current generator. The latter drives a continuous-current motor, geared, or direct-coupled, to the main winding gear, the control of the main winding motor being effected by the well-known Ward Leonard system. The three-phase motor is fitted with slip rings so that resistance can be introduced when required. Of course, the flywheel cannot yield up, or store energy, unless the speed is varied, and, therefore, it is necessary to introduce resistance into the rotor circuit when it is desired to make the flywheel give out energy; and to speed the flywheel set up again this resistance is necessarily cut out.

The main winding gear, therefore, is absolutely dependent on this flywheel system, and should the latter break down in any way, the winding gear cannot be used. Of course, it is necessarily an expensive gear, and to duplicate the flywheel system would add so much to the cost as to make it practically prohibitive, unless the value of the coal burnt at the pit-mouth was very high.

The writer, therefore, thought it was most desirable that the winding motor should be three-phase, and so arranged that it could be worked in case of failure of the flywheel system. With this object in view, therefore, in conjunction with Mr. McLeod, he worked out a series of systems, and made a considerable number of experiments with the same.

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* Abstract of Paper read before the Manchester Section of the Institution of Electrical Engineers, Feb. 19, 1907.

It is well known that the Westinghouse Company have a system which is known as the rotary converter system, and this has been fully described by Mr. Braun at the discussion on Mr. Mountain's paper. This system has the advantage over the Ilgner in that the winding gear can be worked if the flywheel system breaks down.

The first system to describe is called the Cascade Flywheel Storage System. This consists of two three-phase machines coupled together in cascade, and attached to a flywheel, the main winding motor being three-phase. The flywheel set is started up in the usual way by resistance in the rotor circuit of the second machine; the latter is afterwards cut out, the speed of the flywheel rising in proportion. Assuming for a moment that we have a 4-pole and a 2-pole machine in cascade, then if the second machine is in circuit, the speed of the set will correspond to that of a 6-pole machine, and if the second machine is cut out, the speed will correspond to a 4-pole machine. If a circuit of 50 periods is used, this will give, say, 1500r.p.m. and 1000r.p.m. respectively. Assuming that the flywheel set is running with the second machine cut out, the main winding motor is then started up by resistance in the rotor (preferably a liquid resistance tank controlled by a valve allowing the liquid to pass to the resistance box from a tank overhead, fed by a small centrifugal pump). Simultaneously with the starting up of the main motor, the second machine of the cascade is put into service, and the flywheel begins to reduce its speed, the cascade system delivering current back to the mains, and assisting the main supply until the speed attains synchronism, corresponding to 6 poles, *i.e.*, 1000r.p.m.

It is, of course, well known that an induction motor, when running over synchronism, will deliver current back to the supply. This property is utilised in mountain railways when the cars are descending the hills.

As soon as, or before, the current from the main winding motor is shut off, a bar is put across the three wires forming the connections between the two machines in cascade, and the flywheel begins to absorb energy, and speed up to 1500r.p.m. It is then prepared to discharge itself as soon as the main winding motor is started up again. The operations of the motor during the ordinary working day are almost perfectly regular in time of stoppages, &c., for loading and unloading, and the energy required to be stored up in the flywheel can be calculated to the greatest nicety.

The disadvantage of this system is the poor power factor, as the main generator has to supply the magnetising current for the flywheel set under all conditions. The writer does not think that power-supply companies would quite appreciate loads with power factors in the neighbourhood of, say, .5 as an average.

The second system to be described consists of two induction motors, say, a 4-pole and 6-pole, coupled together with a flywheel between. These two machines are not in cascade, but a throw-over switch is arranged so as to connect either one machine or the other to the mains.

It is obvious that when the 4-pole machine is coupled to the mains, assuming that the periodicity is 50 per second, the synchronous speed will be 1500r.p.m., and when the 6-pole machine is coupled the synchronous speed will be 1000r.p.m. Therefore, to store energy in the flywheel, the throw-over switch is put on to the 4-pole machine, and to take energy from the flywheel, the throw-over switch is put on to the 6-pole machine. The latter will then deliver energy back to the mains until the speed of the flywheel is reduced to 1000r.p m. per minute. The disadvantage of this system is that it is somewhat costly, and probably might give trouble with the switch-gear, as the heavy currents have to be made, and broken, on the throw-over switch.

The power factor is better than that of the cascade system, but it still has the disadvantage that the magnetising current for the flywheel system has to be supplied from the mains; therefore, the only logical conclusion to come to was that it was necessary to use a synchronous motor coupled to the flywheel set, which can, if necessary, be over-excited so as to give unity power factor on the supply mains. A synchronous motor necessarily must run at a constant speed, and, therefore, no energy can be put into the flywheel, or taken out, unless either the periodicity be altered or the stator revolved. The latter method offered a very simple means of getting over the difficulty, and resulted in a new patent being taken out for a synchronous flywheel storage system.

As this is undoubtedly the best system of the three, the writer proposes to describe it at somewhat greater length than he has devoted to the other systems.

The flywheel storage set consists of a synchronous motor with a revolving stator; the rotor of this machine is of rather peculiar design, being almost exactly similar to a wound rotor of an induction motor. This motor is started up exactly as an induction motor, that is, with a resistance in each leg of the rotor, this resistance being gradually cut out, as the flywheel attains its maximum speed. Suppose for a moment that we decided to use a 6-pole machine, and the periodicity is 50; this will mean that the flywheel will run at 1000r.p.m. when the stator is stationary. As soon as the speed is near synchronism, continuous current, supplied from another source (such as the exciter of the main generator) is inserted between one leg of the rotor windings and the common junction thereof, the rotor being, of course, star-connected. The motor at once pulls into synchronism, and no phasing indicators are required whatever.

The two unused legs of the rotor winding are then short-circuited and form amortisser windings, the advantage of this being that it gives the synchronous machine a large overload capacity without coming out of step.

The stator is carried on ball bearings from the nose of two pedestal bearings attached to the bedplate, and is geared to a small three-phase, or continuous-current motor, by spur or skew gearing (see illustration Fig. 1).

The writer prefers to have this small auxiliary motor reversible, so that it will run at a speed of, say, 200 revolutions in either direction. It will, therefore, be obvious that when the stator is revolving in the opposite direction to the rotor at, say, 200 revolutions the synchronous speed of the flywheel will be 800r.p.m., and if the stator is revolving with the flywheel at 200 revolutions the synchronous speed will be 1200r.p.m. It is quite easy to arrange to run the stator at a higher speed than this in both directions, if required, but, generally speaking, it is not desirable to vary the speed of the flywheel to the extent of more than about 1 to 1.5. This auxiliary motor is, of course, very often stopped, and therefore it can be assumed that the capacity of it is only about one-fifth of that of the main flywheel motor, allowing for gearing losses. The main winding motor is three-phase, and takes its current at full pressure from the mains, the starting being effected through resistance in the rotor, preferably of the liquid type.

After the flywheel has been speeded up to its maximum (that is, by revolving the stator at 200r.p.m. in the same direction as the flywheel) the main motor is started up, the speed of the flywheel being reduced by gradually stopping, and afterwards reversing the motor controlling the speed of the stator. During this period the flywheel will be giving back energy to the supply mains.

Better control of this system can be obtained by using a small continuous-current motor revolving the stator, this machine being supplied with current from a small continuous-current generator direct-connected to the flywheel storage system, these two machines being controlled by the Ward Leonard system, the excitation being effected from the exciter on the main generator.

In order to control the main winding motor, it is necessary first to have a lever arranged to open a valve, and admit water to the resistance tank connected to its rotor; at the same time, this lever must control a Ward Leonard shunt rheostat which controls the speed of the stator case.

In pointing out the advantage of this system as compared with the one using continuous current for the main winding motor, attention must be called to the fact that it is possible to use a flywheel running at a high speed. With this construction we can use a comparatively light flywheel, as it is possible to obtain a flywheel built up of armour plate which can run at a peripheral speed of 28,000ft. a minute, and with a large factor of safety. Such wheels are made and can be guaranteed by manufacturers in this country.

It is necessary to use a slow speed on the Ilgner system owing to the fact that a continuous-current dynamo is attached to one end, and this dynamo has to work under very difficult conditions. It must, of course, be capable of delivering its full current with practically no volts, and although it is fitted with interpoles, it is not possible with present practice to run these flywheel sets at a very high initial speed.

In flywheel systems where a large amount of energy has to be stored up in the flywheel, it therefore becomes almost impossible to build a flywheel which can be transported on the railway for these slow speeds. These flywheels necessarily must be made of the plate pattern, and in one piece, and unless the colliery is situated at, or near, a seaport town, it is practically impossible to transport the flywheel to the site on which it is to be used. The three-phase flywheel storage system does away with this difficulty, as the flywheels are of comparatively small diameter. They are also lighter on account of the considerable amount of energy which can be stored up in the rotor of the synchronous machine.

It will be observed that in the system described the full power required for the motor does not pass through the flywheel set, which simply acts as a buffer dealing only with such proportion of the current above that previously determined to be taken from the generator or source of supply, the normal energy going direct to the main motor without being transformed in any way. This, of course, means low capital cost, as the flywheel system is of relatively small capacity and high efficiency, the major part of the current being supplied direct to the winding motor.

Attention must also be called to the fact that in many collieries it is required to run the main winding engine intermittently during the night for lowering timber, &c., and for lifting water. With the above system the flywheel set can be shut down entirely, and the main motor simply run on a slower acceleration in order to keep down the peaks. There is also, as a rule, plenty of reserve power on the main generators during the night time, as the electric hauling engines down the pit, in addition to many other motors, will not be at work. Under these conditions, therefore, it is better to shut down the flywheel set at night altogether. Attention has been called to the fact that by varying the exciting current of the flywheel set, the power factor on the mains can be raised to unity if necessary; but, of course, it is not desirable to do this to a too great extent owing to the fact that magnetising current does not represent energy, and, therefore, the flywheel set cannot help the main motor much if it is delivering wattless currents for magnetising to a too great extent.

A group of two or three main winding engines within reasonable distance for a high-tension transmission can be advantageously driven from one central station

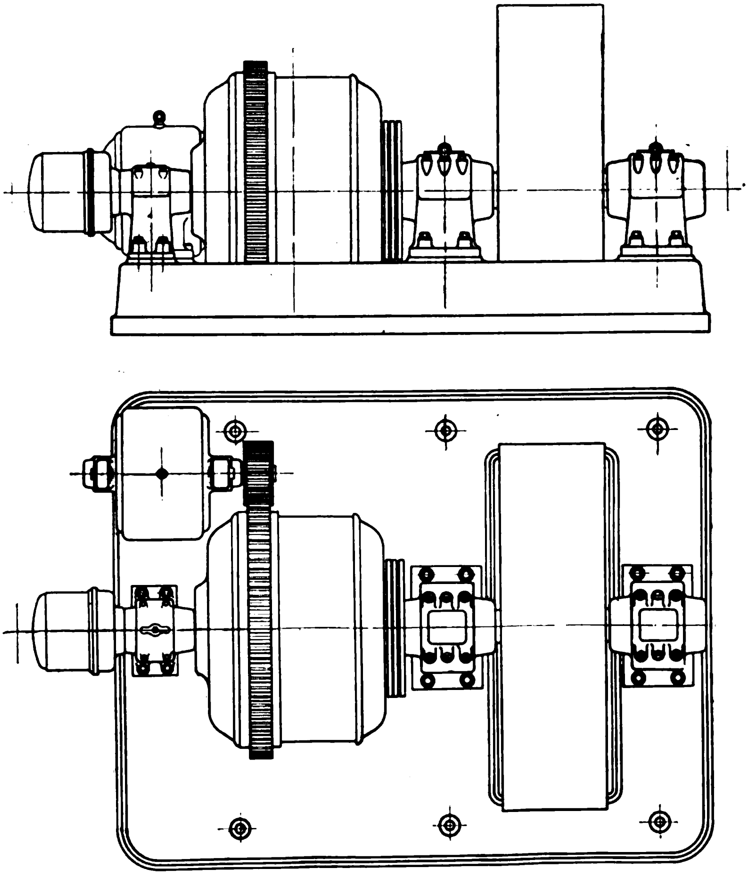

Fig. 1. Flywheel Storage set for Three-phase Winding Gear.

with one common flywheel storage set. The flywheel storage set in this case is controlled by a solenoid or small induction motor actuated by the main current coming from the generator and starting, stopping or reversing the small motor driving the stator on the flywheel set according to the current demanded by the various winding motors.

This method can also be applied to equalise the load on any system (a group of rolling mills, for instance).

In comparing the cost of running of electric as against steam winders, the comparison ought to be made on a proper basis. It is generally admitted that electric power is desirable for practically all other operations in the pit, and, therefore, the cost of this generating plant ought to be taken into account in comparing the two systems.

Assuming for a moment that the auxiliaries require 1000kw. with steam winding, this would mean three generating sets each of 500kw., allowing one set as a spare. With electric main winding taking an average load of, say, 800kw. from the mains, making a total load of 1800kw., the total capacity of the generating plant required would be 2700kw., assuming that we have a standby set of 900kw., *i.e.*, three sets of 900kw. each.

The first cost of the larger plant will be considerably less per kw. than the smaller, and the coal consumption per kw. hour will be less.

The first cost of the boiler installation will be considerably less with electric winding and there will be no difficulty in using water-tube boilers, which are perhaps more suitable for burning low-grade fuels and for large powers.

Water-tube boilers can only be used with success with steam winding if there is a considerable amount of steam taken for driving other engines, as the water-tube type is not suitable for the heavy drafts of steam required in steam winding.

Continuous-current Systems.

The two systems to be briefly described in this paper we will call the Booster Flywheel Storage System and the Compound Flywheel Storage System. In the former a plain shunt-wound generator excited across the mains is attached to a heavy flywheel, and its armature is coupled up in series with an automatic reversible booster, constructed according to the Turnbull and McLeod patents. This booster has been very fully described in papers read by Mr. Turnbull and Mr. Kelsall before the Institution. The main flywheel dynamo simply takes the place of the battery, and if the demand on the line is heavy, the booster will give a voltage in such a direction as to pull current out of the flywheel dynamo, and when the demand on the line is small the booster will give a voltage in such a direction as to charge or speed up the flywheel set. The speed of this flywheel set will correspond directly to the voltage across the armature terminals, as the dynamo is excited at constant pressure across the mains.

The compound flywheel storage system consists simply of one machine which acts alternatively as generator and motor, and is, of course, coupled to a heavy flywheel, and worked in conjunction with automatic switch-gear to vary its field strength. In the typical case, briefly stated, the auxiliary machine is compounded to give constant external volts at all loads, whether motoring or generating. Its armature is connected across the mains between the generating plant and the fluctuating load, and its fields are equipped with a special series coil, carrying the generator's load, or some proportion of it. As long as the flywheel auxiliary's speed remains the same, the generator's load cannot alter, for the smallest tendency of the generator's current to increase strengthens the auxiliary machine's field, causing a generating response, and similarly the smallest tendency of the generator's current to diminish causes the auxiliary set to motor. As the auxiliary set speeds up, due to motoring, the automatic switch-gear diverts an increasing fraction of the generator's current from flowing through the special coil of the auxiliary set, so that the field of the auxiliary set is gradually weakened without diminution of the load on the generating plant. Similarly as the auxiliary set slows down, due to generating, the automatic switch-gear gradually reduces the fraction of the generator's current diverted from flowing through the auxiliary's field, so that the auxiliary's field is strengthening, without increase in the load upon the generator. However much the load varies the demand upon the generating plant is only the average demand, all the excess demand of the peaks being supplied by the auxiliary set from energy stored during the valleys of demand.

The method adopted by the British Westinghouse Electric and Manufacturing Company, Ltd., is suitable with corresponding modifications for the operation of winding engines by either alternate-current or direct-current motors.

The diagrams Figs. 2 and 3 show the connections and general arrangement of the "Westinghouse converter-equalizer" system as adapted for the use of direct-current winding motors. The rotary converter (1) is connected to the high-tension alternating-current mains through transformers, the direct-current side being joined-up to a direct-current machine (2) fixed on the same shaft as the direct-current regulating machine (3). The latter is electrically connected in series with the machine (2), and acts as a voltage-regulator by means of which a variation of voltage on the winding motor terminals (4) between minus maximum and plus maximum is obtained. The direct-current voltage of the machines (1), (2), and (3) is one half of the maximum voltage of the winding motor (4), so that if the latter is built for 500 volts, the voltage of the former will be 250 volts.

When the winding motor has to be started the voltage of the regulating machine (3) will be equal and opposite to that of the machine (2). By decreasing gradually the voltage of the machine (3) to zero and increasing it in the reverse direction, any desired pressure between zero and maximum may be applied to the winding motor. In order to regenerate it is only necessary to decrease the voltage impressed on the winding motor. The energy will always be taken from the alternating-current supply circuit with approximately 100 per cent. power factor; or leading current may be delivered to it by properly regulating the shunt field of the rotary converter.

For the use of alternate-current winding motors the arrangement is similar to the foregoing so far as the step-down transformers and rotary converter are concerned. On its direct-current side, the rotary converter is connected to a direct-current machine acting sometimes as a generator and sometimes as a motor, and fitted with a flywheel. The rotary converter is compounded in a special way so as to supply automatically the magnetising currents required for the induction motors on the system. The voltage of the direct-current flywheel machine is controlled automatically by a quick-acting regulating apparatus which is actuated from the high-tension transmission line through series transformers. The action of this whole arrangement is to discharge energy into the high-tension line system whenever the load on the latter is greater than the constant output; and to store up energy in the flywheel whenever the power demand in the high-tension supply system is less than the constant output of the station.

When there is no load on the high-tension system, the rotary converter runs with approximately 100 per cent. power factor, and gives up to the flywheel—through the medium of the d.c. machine acting as a motor—energy corresponding to the constant output of the station, until the

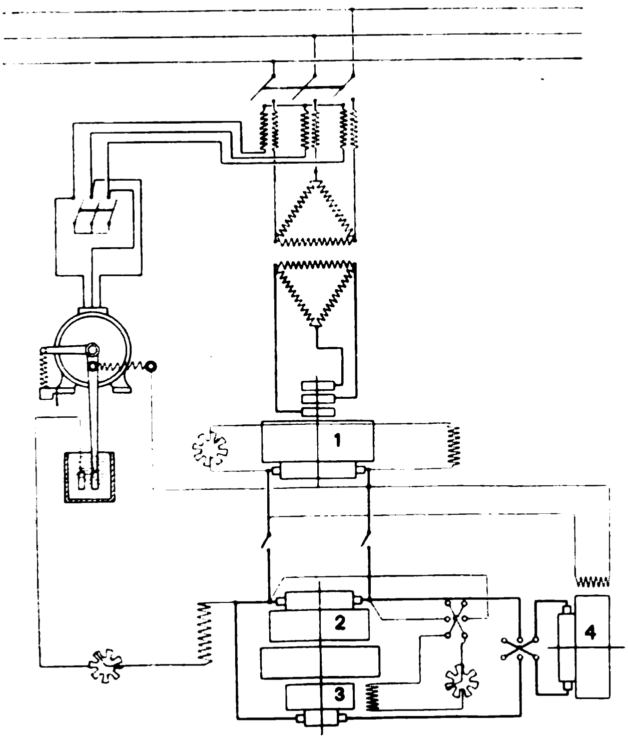

Fig. 2. Diagram of the Westinghouse Converter-equalizer System of Winding, with Direct-current Winding Motors.

maximum speed is reached. The flywheel is of sufficient capacity to take care of the overload and underload periods. The flywheel machine is preferably built for high speeds in order to obtain high electrical efficiency with light weight; and may have a maximum slip of 40 per cent. of its maximum speed, though in ordinary service 30 per cent. slip is sufficient.

The diagrammatic sketch (Fig. 4) shows the electrical and mechanical control-gear used in conjunction with the Westinghouse converter-equalizer's system when applied to a winding engine driven by a polyphase motor.

The drum or friction-wheel brakes are normally actuated by the compressed-air cylinder *B*; or—in case of emergency—by means of a weighted lever *C*.

The whole control gear is operated by means of three levers, *a*, *b*, and *c*, which are fixed on the driver's platform. The lever *a* on the right-hand side of the driver actuates the main reversing switch *D*, and the liquid starting rheostat *E*.

The lever *a* can be moved either forwards or backwards from its central or off position, the position of *D* and the direction of rotation of the winding motor depending on this. When the lever *a* is moved, the switch *D* is actuated first, the movement of the liquid starter *E* being secondary, beginning only after *D* has reached a definite position. If the lever is moved into an intermediate position the reversing switch is operated as before, viz:—to its full final position, whereas the liquid starter is only moved to a position corresponding with that of the operating-lever handle. In this manner the speed of the winding engine can be varied within wide limits. The action of the liquid starter is such that the acceleration is automatic, and quite independent of the speed with which the lever *a* is operated. Should, however, the handle *a* be moved so slowly that the amount of water supplied to the upper tank of *E* exceeds its holding capacity, the acceleration will be less than the normal.

The design of the control gear is such that the electrical braking of the motor when lowering may be arranged for if necessary. The lever *b*, fixed on the left-hand side of the driver, operates the pneumatic brake through *B*. The foot lever *c*, which is between the two others, and is only operated by the driver in cases of emergency, when it is required to stop the winding drum at a moment's notice, acts as follows: it releases the weighted brake lever *C*, which is normally held up by the mechanism *d* and *e*; it opens the emergency switch *F* by means of the rods and links *d*, *e*, and *f*, thus cutting off the supply of current to the motor.

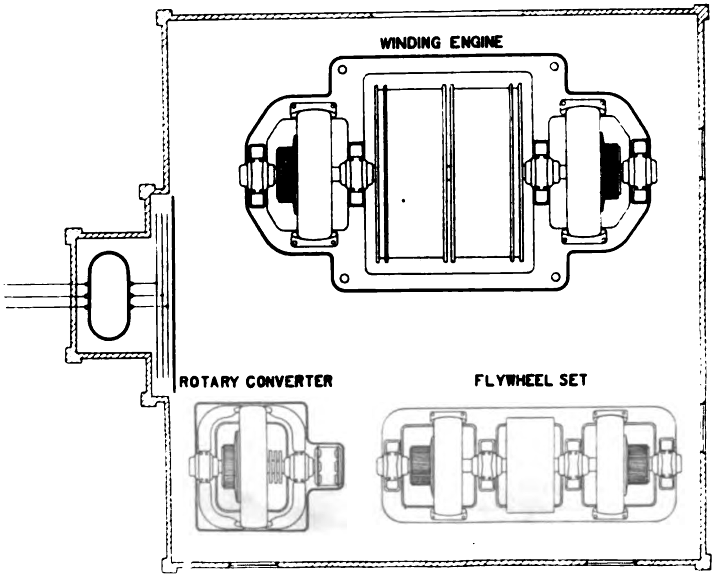

FIG. 3. PLAN OF MACHINES USED IN THE WESTINGHOUSE CONVERTER-EQUALIZER SYSTEM OF WINDING USING DIRECT-CURRENT WINDING MOTORS.

The drum will also be stopped automatically, in the event of overwinding or a failure of the electricity supply. The provision for this is as follows: the tripping mechanism of the emergency brake lever is connected mechanically to the depth indicator *G*, by means of rods and links *g*, *h*, *i*, *k*, and *e*, and the emergency brake lever *C* will be released at the end of the travel in case of overwinding, the emergency switch *F* being operated at the same time through the extra link *f*; an abnormal fall of voltage or failure of

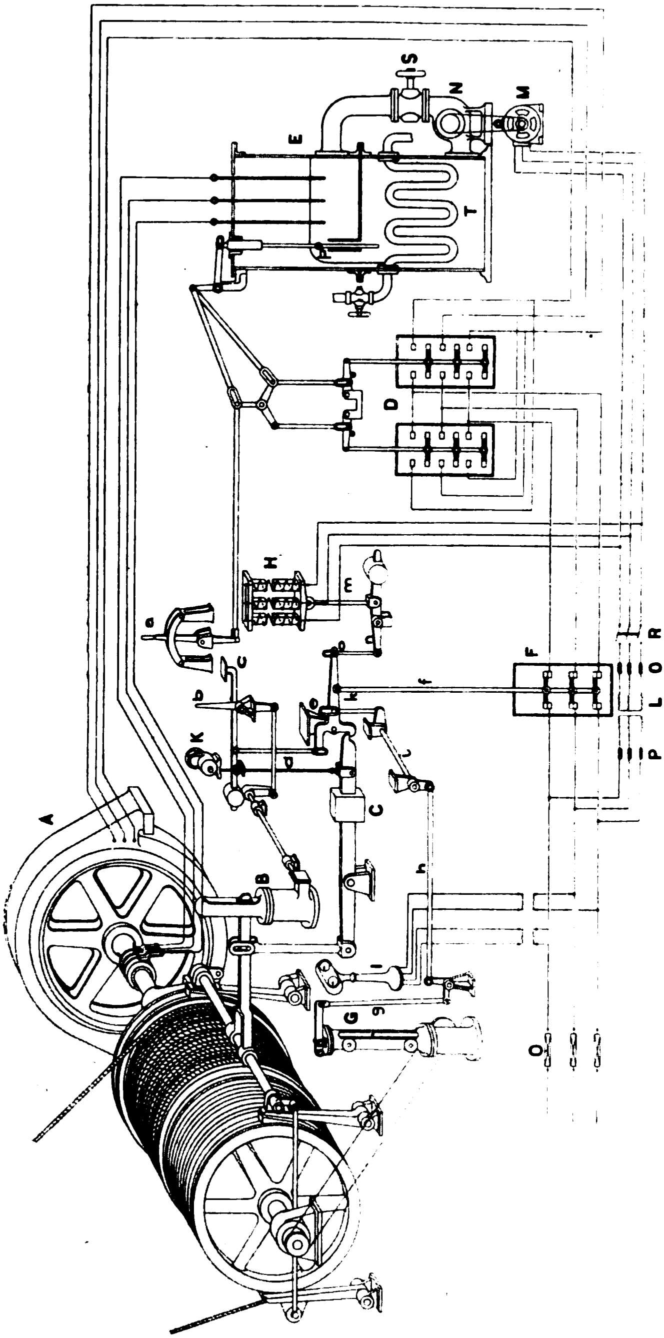

Fig. 4. Diagram Showing the Control of the Westinghouse Converter-equalizer System of Winding using Three-phase Winding Motor.

the supply will cause the solenoid cores *H* to drop, and the emergency brake to be released through the link motions *m*, *n*, *o*, and *e*, the emergency switch being also thrown off through *m*, *n*, *o*, *e*, and *f*. The replacement of the weighted brake lever *C* is effected by means of a winch *K*. The Westinghouse system of electric winding exhibits many features of particular importance and advantage. Only that amount of energy is converted into direct-current and back into polyphase current which is in excess of or below the constant output of the station. It is therefore a direct system, and enables polyphase motors to be used for winding, so that the motive energy can be derived straight from the polyphase main supply which is now generally employed in mining work, and which has proved superior to direct-current working.

As the converter-equalizer has only to deal with the fluctuations in the demand on the power station, and does not transform the total energy required by the winding and other motors, it follows that the capacity and capital cost of the machines required, and the energy loss involved, are considerably reduced; that one converter-equaliser can be used to equalise the variable load of an entire system, there being no necessity to provide an equaliser for each winding engine; and that the converter-equaliser may be connected at the most convenient point in the high-tension line, without regard to the location of the winding motor.

When a separate motor-generator is employed for transforming the total energy necessary for each winding engine, the latter must be shut down in the event of any repair being necessary to the motor-generator. In this system, in the event of any breakdown of the converter-equaliser, the winding engine can still be operated at a load corresponding to the capacity of the main generating plant. On light loads, especially during night-time, when the output—as a rule—is small, the converter-equaliser may be shut down if necessary without affecting the winding engine, &c. This is obviously not possible with a flywheel motor-generator, even though under such conditions its equalising capacity is not required, and its load factor is very low.

The economical speed-variation of a flywheel motor-generator is limited, as it must be obtained by reducing the efficiency of the motor to approximately the same amount, by inserting resistance in the rotor circuit. Under these conditions, a larger speed-variation than twelve per cent. involves too excessive a loss. In the converter-equaliser the speed is automatically regulated by a resistance in the shunt circuit of the direct-current machine. The loss of power through field regulation is so small as compared with the total capacity of the machine as to be negligible, thus allowing a slip of from zero to sixty per cent. or more without appreciably lessening its efficiency. As previously mentioned, however, a slip of thirty per cent. will be sufficient, as it will enable the flywheel to part with about fifty per cent. of its total kinetic energy. The necessary weight of the flywheel is thus reduced to approximately one-third of that requisite in the case of a motor-generator system of the same output. This is a point of the greatest importance in designing, handling, and starting-up such machines.

To the winding system of Messrs. Siemens belongs the distinction of being probably the first to come into practical use, and the record of some fifty installations in regular service. Several of these have been in successful operation for three years, and that period has fully proved, once and for all, that electric winding is successful both in the mechanical and economic senses. The Siemens-Ilgner system introduced the principle of mechanical storage of energy to level up the load on the power generator, a flywheel storing up energy when the winding motor is doing light duty and yielding energy to assist the generating plant when the winding motors are on the heaviest part of their service.

From the mains of an electric power station, current is drawn for driving a motor-generator or converter transforming the supply current into direct current at variable voltage, and this is used for driving the winding motor. Either a continuous or three-phase supply is thus suitable for driving the motor-generator. The converter is provided with a heavy flywheel, in the form of a single steel casting or forging, which is capable of running with safety at a high circumferential velocity.

The energy which is stored in the flywheel is drawn upon for taking up the fluctuations in load of the winding engine, and equalising the demand upon the power station. The converter-generator and the winding motor are both of the direct-current type. They are separately excited, and when the supply is single- or three-phase, the exciting current, which does not exceed 2 or 3 per cent. of the total current, is obtained from a small direct-coupled dynamo.

The armatures of the converter-generator and winding motor are connected in series. A set of regulating apparatus is supplied by which the exciting current of the converter-generator is varied at will from zero to a positive or negative maximum. The degree of excitation determines the voltage generated and applied to the terminals of the winding motor armature, and the revolutions of the latter vary approximately in direct proportion.

The winding motor is either direct-coupled to the drum or drives the drum through single-reduction spur gearing. The former arrangement has advantages in simplicity of construction and freedom from noise in working, and is usually the most practical for plants of larger sizes. For smaller plants, however, it is more costly than the geared arrangement. In very large plants two coupled motors, one on either side of the winding drum, are sometimes used. This arrangement is chiefly advantageous in giving extra security against breakdown, since in an emergency one motor can be used to wind at half speed.

In addition to the regenerative braking action of the winding motor described later, working brakes are used which are similar to those employed with steam gears, except that they are operated by compressed air supplied by a small special compressor electrically driven. The compressor is mounted on a receiver having enough capacity to ensure a sufficiency of air at all times. The compressor is automatically stopped or started as the air pressure in the receiver rises or falls between given limits.

In proportioning an electric winding plant, the winding motor and the converter generator, which supplies it with current, must be chosen of ample size for providing the actual power represented by the lifted weight and for accelerating all the moving masses, such as the loaded and empty trucks, cages, rope, drums, and motor armature up to the maximum speed. The power required for acceleration is a large factor of the total, especially with high winding speeds where the maximum sometimes reaches 4000ft. per minute. In the diagram, Fig. 5, are shown actual load results taken from an electric winding engine. The high peaks at the beginning of the cycles show the power taken during the accelerating periods. It is about twice that taken during the following, or constant speed, periods. With the double cylindrical or conical drum winders and the high winding speeds employed in this country, the relative power required for acceleration is even greater than shown in the diagram. With Koepe pulleys, which have met with considerable favour abroad, the total weight to be accelerated is reduced, and the tail rope with its balancing effect serves to equalise the load diagram to some extent; but even with these the power during acceleration, and during the constant-speed period, is very disproportionate.

With the steam winding engine, not only is it impossible to utilise the steam efficiently owing to such wide variations of power, but the work done in acceleration and retardation is entirely lost. In the Siemens-Ilgner electric winding system this does not occur. With the winding motor constantly excited to a given amount, and supplied with an armature current of varying voltage, its efficiency remains practically constant at all loads. Moreover, the power given out for acceleration at the beginning of the wind is regained at the end, because the winding motor then acts as a generator, absorbing the power given out by the moving masses during their retardation and reconverting it into power, which is stored in the flywheel of the motor-generator.

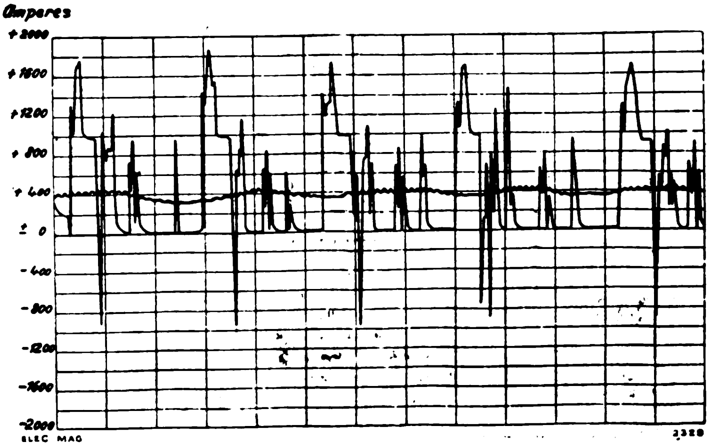

FIG. 5. LOAD DIAGRAM OF A SIEMENS-ILGNER ELECTRIC WINDING SET.

On the other hand, it should be mentioned that with the converter interposed between the supply and the winding motor, some power is lost in conversion, and in keeping the converter constantly running. This loss amounts to about 15 per cent. of the total energy supplied, but the resultant economy much more than compensates for it.

In actual practice it is found that the steam consumption at the generating station with such a system is only from one-third to one-half as great as the steam consumption of the best modern winding engines. Remarkable as this result may seem, it is fully confirmed both by tests and by records extending over long periods.

For completely controlling the winding motor and braking gear there are only two levers. The one at the right hand of the operator, shown in Fig. 6, is the control lever for the winding motor, and the one at the driver's left hand is the brake lever. The two levers are interlocked, so that when the machine is put in motion the brakes are released, and when the current is cut off they are again applied. The reversal of the gear is effected by moving the control lever to one side or the other from its "off" position; that is, the driver either pushes the lever from him or draws it towards him.

As mentioned before, the movement of the control lever merely varies the excitation of the converter dynamo. For this purpose a field rheostat is provided which is operated by a pinion and sector moved by a rod from the control lever. The field regulator is provided with a large number of steps in both directions, so that exceedingly small gradations in speed are obtainable. By moving the control lever only a small distance from the "off" position, the cages are driven at a "creeping" speed of only 1 or 2ft. per second, which is admirable for inspecting the shaft. These slow speeds, moreover, are perfectly constant and free from the pulsations unavoidable in a steam-driven engine. By moving the control lever further from the "off" position, the gear rapidly and uniformly accelerates in speed. By moving the lever back towards the "off" position, and thus reducing the excitation of the converter dynamo until its electromotive-force falls below the back-electromotive-force of the winding motor, the latter acts as a generator, and tends to bring the gear to rest while it regenerates the energy thus absorbed.

A special device is sometimes provided for lifting or lowering passengers. When a gong on the bank signals the approach of the empty cage, a stop is automatically operated in the frame of the control lever, which prevents the lever being pushed beyond the point corresponding with the proper speed for carrying men. Below this speed, however, the driver is still free to vary the speed as desired.

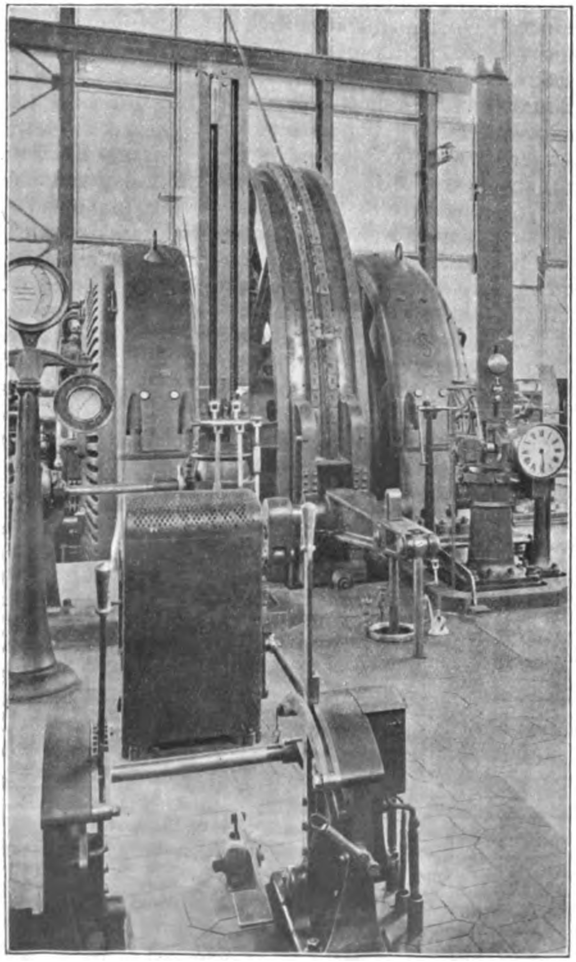

FIG. 6. SIEMENS-ILGNER ELECTRIC WINDING ENGINE, WITH KOEPE PULLEY.

It will thus be seen that the speed of the motor is definitely determined once and for all by the position of the control lever, and entirely independently of the continual changes of load; and it is only necessary for the driver to handle the control and brake levers for starting, regulating, stopping and manœuvring the gear as may be necessary. This compares very favourably with the methods generally adopted for controlling steam winding engines or electric winding engines designed on other systems.

To show the driver the exact position of the cages at every moment, a depth indicator of novel design has been perfected and forms part of the controlling and brake gear of the system. This apparatus consists of two vertical screws driven by gearing from the main winding shaft and carrying pointers which move over vertical scales. At the bottom of the frame and driven by worm gearing is a wheel which makes one revolution during the lift. This wheel has on its periphery four cams which engage in rods connecting with the control and brake levers. The cams are so shaped that it is impossible for the driver to start the gear too quickly, and they also serve to bring the control lever automatically to the "off" position and apply the brakes when a hoist is completed.

In addition to this apparatus for

automatically controlling the gear and making it impossible for the driver to start too quickly, or for an accident to occur through negligence in control, there is also provided, as a further safeguard, a special safety brake gear constructed as follows.

A counterweight actuating the lever of the safety brake is supported by compressed air acting upon the piston of the brake cylinder, which is fitted with a three-way cock through which connection is made either with the air receiver or with the atmosphere. So long as the pressure in the receiver is maintained, the safety brakes are held off, and the working brakes are free to act; but should the pressure fall or a leak occur, the safety brake acts automatically on the drum, and the counterweight in falling throws over an emergency switch and cuts the winding motor out of circuit. The driver cannot start the engine again until the pressure is restored. The safety brakes may also be put on by the three-way cock being turned either by hand or, in the case of the bank being over-run, by the depth indicator. It is also possible for them to come into operation should the speed become excessive, but this could only happen by some part of the control apparatus breaking down. The air in escaping being throttled by a special regulating valve, the safety brakes are applied gradually and without shock.

The method by which the safety gear is put into action by the depth indicator deserves remark. The cams on the depth indicator are so arranged that when they force the control lever gradually back towards the "off" position the working brakes are automatically applied, and tend to slow down the gear. At this period it is possible for the driver to stop the motion by pulling the lever to the "off" position, and then manipulating it so as to bring the cage slowly to the bank. The driver can then only start in the reverse direction, and can increase the speed of the gear gradually as permitted by the cam, which is arranged to suit the maximum acceleration required. Should the driver miss stopping at the right moment and slightly over-run the bank, rods, operated by the cams, open the three-way cock of the safety brake cylinder. The safety brake is thus applied, and brings the winding drum quietly to rest. The whole apparatus is thus entirely automatic, and makes it practically impossible for an accident to occur through mis-handling, or through the driver losing his head at a critical moment.

The following is a short description and summary of an official test made on the Siemens-Ilgner plant installed at Pit Zollern II. of the Gelsenkirchener Bergwerke A.G., Merklinde.

At this pit coal is at present being wound from a depth of 200yd., but the depth will be increased subsequently to 550yd., and the winding engine was designed accordingly. The winding engine, Fig. 6, is equipped with a Koepe pulley and two direct-coupled winding motors, driven by a flywheel motor-generator. The capacity of the plant is 1360 to 2000 tons in eight hours. The cages are three-stage and carry six trucks. The maximum hoisting speed is at present 33ft. per second, but this will be increased later to 65ft. per second when winding from the full depth.

The generating station is at the pit mouth. There are two 1100kw. generating sets, with triple-expansion engines. The steam pressure is 185lb., and the engines are worked condensing. Continuous current at 525 volts is generated. This is used for driving two large compressors, a ventilating fan, the winding engine, several smaller motors, and for lighting. One generating set is normally in use, the other being held in reserve. A complete test of the plant for ascertaining the steam consumption of the engines, and for determining with accuracy the distribution of power between the winding engine and various motors, was carried out over 24 hours, from 6 a.m. on the 25th November, 1904, to the same time on the next day. Readings were taken every 15 minutes. During the time mentioned 3127 trucks, containing in all 2423 tons of coal, were wound in the two working shifts. At the changes of shifts, 1024 men were taken down and 1007 men brought up; the weight of the men was averaged at 165lb.

The effective h.p. in the shaft was calculated from the depth and the effective load. By effective h.p. in the shaft is meant that represented in the actual weight of coal and men wound, not including the power required for acceleration and for hoisting trucks, cages, &c.

The results of the test were as shown in the table on next page. It should be noted that the steam consumption was ascertained by weighing the water delivered to the boilers during the test.

DISTRIBUTION OF POWER OVER THE SEPARATE SHIFTS.

	6—2. Morning Shift.	2—3. Winding Men.	3—10. Noon Shift.	10—6. Night Shift.
Total kw. hours delivered by generating plant	9076.330	715.820	7506.750	4770.79
Total steam consumption, lb. . .	168,250.000	14,110.000	137,520.000	97,465.00
Steam consumption per kw. hour	18.536	19.710	18.318	20.43
Kw. hours absorbed by winder	2192.070	83.960	1577.180	552.18
Effective h.p. hours in shaft	1562.000	13.053	990.130	92.00
Kw. hours per effective h.p. hour in shaft	1.403	6.430	1.592	6.00
Steam consumption per effective h.p. hour in shaft in lb.	26.010	126.770	29.178	122.62

SUMMARY FOR THE TWENTY-FOUR HOURS.

Total kw. hours delivered by generating plant...	22069.69
Total steam consumption	417345.00lb.
Total steam consumption per kw. hour	18.91lb.
Total kw. hours absorbed by winder	4405.39
Effective h.p. hours in shaft	2657.183
Kw. hours per effective h.p. hour in shaft ...	1.657
Steam consumption per effective h.p. hour in shaft	31.35lb.

The Electrical Company, Ltd , of London, are also in the advantageous position of being able to cite many instances of the application of their methods of electrical winding. In Germany, France, Austria, and Belgium, the Continental relatives of this well-known firm have for some years established a reputation for these specialities.

One of the most recent of these installations is that at the Preussen Pit No. 2 of the Harpener Mining Company, Dortmund; a general view of the winding room is given in Fig. 7. The plant is designed for winding 100 tons of coal per hour from a depth of 765 yards. The winding engine is built on the Koepe wheel system; the winding drum of the wheel consisting of a single-groove pulley, round which the rope passes once, the two ends being attached respectively to the two cages. The great advantage of this system of winding is the very small inertia which has to be overcome in accelerating, thereby reducing the peaks of the load during this period. The wheel has a diameter of 19ft. 8in., and the wire rope 1.77in. The speed of winding is 52ft. 6in. per second. The various details of the weights are given below:—

	Tons.
Useful load: four trucks, 1210lb. in each ...	2.16
Cage and gear	3.74
Four trucks, weighing 772lb. each	1.37
Rope, about 2395ft. at 4.5lb. per foot ...	4.81
	12.08

The Koepe wheel is driven by an electric motor, and is mounted, together with the rotor of the motor, on one shaft, supported by two bearings. A three-phase current at 2000 volts pressure is supplied to the stator of the motor; the motor and the wheel run at a speed of 51r.p.m.

The controller gear is of the most adequate description, and in designing the mechanical and electrical safety devices, every precaution is taken to guard against all possible causes of accidents or breakdown.

The controller itself is operated by a single lever, which is moved forward or backward to correspond with the direction

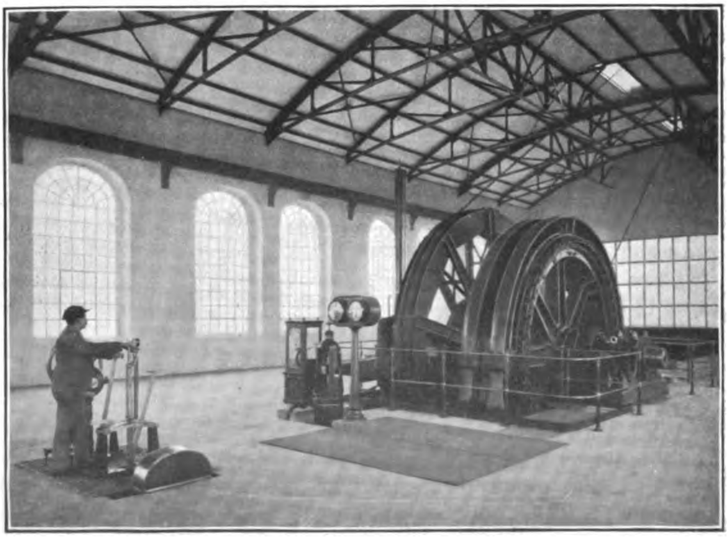

FIG. 7. EXAMPLE OF THE ELECTRICAL CO.'S WINDING PLANT, WITH KOEPE PULLEY.

of rotation of the Koepe wheel, the distance to which it is moved in either direction controlling the speed at which the wheel rotates. The controller is of a patent liquid-resistance type.

The wheel is provided with two heavy slipper-brakes on each side, which are normally operated by a compressed-air cylinder. They are also arranged to be brought automatically into operation if—(*a*) overwinding takes place; (*b*) the current fails from any cause; (*c*) the winding speed exceeds a certain limit.

They can also be brought into operation by an emergency release actuated by a pedal near the attendant's stand.

The central station in which the whole of the energy for the Preussen Mine is generated is not far from the winding engine, and contains three steam-driven generators of 800h.p. each, with the very economical steam consumption of 12.5lb. per indicated h.p. hour.

The tests made to ascertain the actual amount of energy required for the winding engine gave very satisfactory results. As the whole of the mine is not yet developed, and a part of the load will only come on to this generating plant in about a year's time, artificial resistances were added to the existing ones. By tests on a large scale, it has been found that the amount of steam per pit h.p. hour in lifted coal is 33lb.: a figure which is a strong advocate for this system.

Winding Economy and First Cost.

Where it is necessary to instal a new generating plant or to increase an existing one, the investment in boilers required for the Siemens-Ilgner flywheel system will be one-half to one-third of the amount required for an equivalent steam plant or an electric plant drawing its power direct from the main supply.

The reason for this is that the power is taken at an approximately uniform rate, and that the great proportionate amount required for acceleration is regenerated as already described. The cost of attendance and repairs upon boilers is reduced in proportion.

The consumption of steam in Siemens-Ilgner plants where the frictional and mechanical losses are not excessive, amounts per effective h.p. hour expended in the shaft to from 24 to 33lb. of steam, depending upon the efficiency of the steam engines in the central station.

The question as to the advisability of installing an electric rather than a steam winder does not admit of a general answer, but depends upon the conditions to be met with in each individual case. If we consider the cost of the winding engine alone, the electric engine is usually more expensive than the steam engine. If, however account be taken of the extra boiler plant which it is necessary to have with the steam winder, on account of its lower efficiency then it is usually found that the electrical installation will involve little, if any, greater capital expenditure than that required for a steam plant.

Even where the first cost of the electric plant exceeds that of the steam plant the additional investment is warranted by the saving in operating expenses. In several cases from which actual figures of consumption have been taken it is found that the saving amounts in round figures to 33 per cent. per annum on the extra investment, so that the additional capital expenditure is covered in three years.

The above applies to plants in which it is necessary to generate power at the pit. Where the power can be obtained from a supply company, or from a generating station situated centrally so as to supply several pits, the above arguments apply with even more force.

It sometimes happens that the only use of steam at an isolated pit is for the winding engine, all other machinery being driven electrically. In such a case the reasons for the conversion of the winding engine as well are so plain as to hardly need pointing out.

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Electrical Haulage.

There are few power applications wherein electricity reveals greater advantages than when the electric motor is adopted for the driving of haulage gears in mines. Great economy, combined with reliability and absolute safety, are the universal attributes of this modern method. It is not possible to enter here into details of the haulage engines or gears themselves, whether they are of the main-and-tail, endless, or any other type; or of sizes from the light portable outfit to the heaviest stationary main haulage of hundreds of horse power—electric power is now regularly employed for their operation, and the results are always successful. Consider for a moment the intermittent nature of the load, and the economy of electric power is apparent as compared with steam. The motor consumes energy at a rate practically proportional to the load on the rope; and more important still, as with main-and-tail haulages, when the gear is standing no power loss is incurred at all. The motor is essentially a reversible machine, and capable of an accurate speed control over wide ranges and in either running direction. Automatic cut-outs and brakes connected with the electric supply safeguard the equipment and prevent the possibility of any serious accident on the road or to the gear in any way. The space occupied and the foundations necessary for an electric haulage are reduced to a minimum.

Polyphase alternating current and direct current are equally serviceable for this class of work, and, as will be seen from the several examples which follow, are both in very extensive use.

During the last three or four years, the electrification of main-road haulages in collieries has received the greatest attention, and it is for this work that electricity has proved to be pre-eminently the power to adopt. The more general type of haulage is fitted with a fast-running motor and double-reduction spur gearing, although many engineers prefer single reduction and slow-speed motors in order to reduce the noise as much as possible, but this means a considerably more costly and less efficient motor.

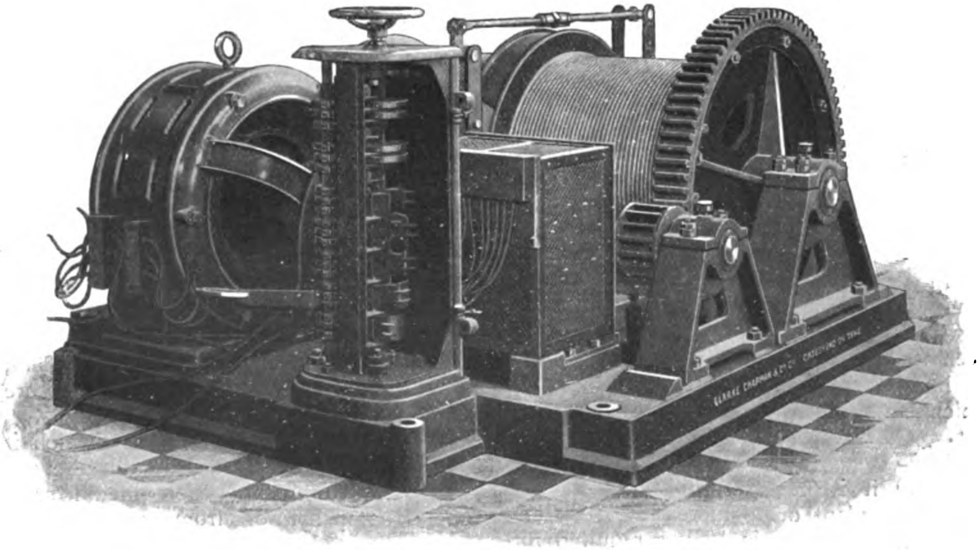

Fig. 1. Clarke, Chapman Haulage Gear—215h.p. Three-phase—Windsor Coal Company, South Wales.

The first two illustrations are of typical haulage plants as constructed by Messrs. Clarke, Chapman & Co., Ltd., the well-known Tyneside firm who have made the electrical equipment of collieries a speciality. The gear shown in Fig. 1 is one of a pair installed at the Aber colliery of the Windsor Coal Company, South Wales. The maximum unbalanced strain on the rope is 10,000lb. at 528ft. per minute. The two gears are fixed at the bottom of the down cast pit on wood beams above the track. Each gear consists of a 215b.h.p. three-phase motor, 440 volts, driving the two drums through two pairs of cast-steel spur wheels, the first motion being machine-cut, and the second motion machine-moulded. The drums are of steel plates riveted to cast-steel cheeks. They are loose on the shaft, and driven by clutches of the double-cone friction type, operated from the driver's platform by means of a combination of levers and screw gear. The drums are fixed against end movement by collars on the shaft, and the driving portions of the clutch are put in gear by the levers and screw mentioned above. Powerful brakes are fitted to each drum, the brakes being arranged for use either by foot levers or screws, and are of the post type. The beds are built up of channels and plates, strongly tied together and forming a compact and massive arrangement.

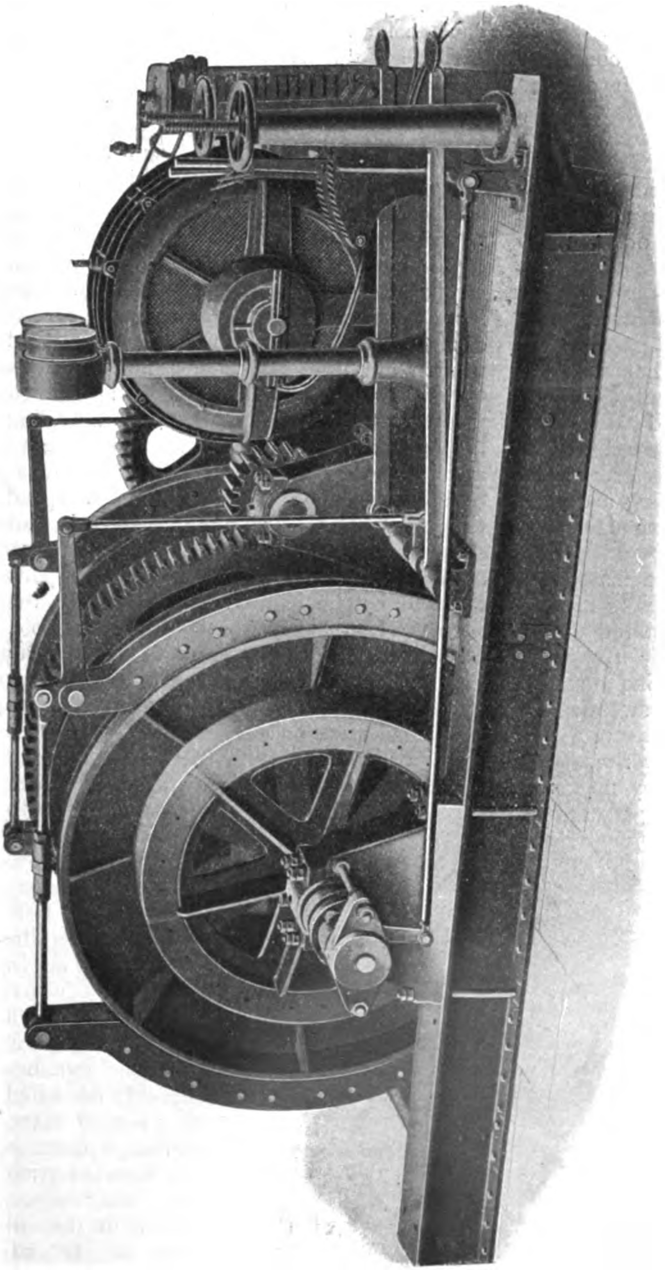

Fig. 2. 30H.P. Double-track Haulage Gear, by Clarke, Chapman & Co., Ltd.

The controllers are of the tramway type, reversing and speed regulating, the resistances being of the cast-iron grid type.

The drums are not moved into gear, the driving portion of the clutch being moved. The drums, being built up of steel plates, are easily renewable when worn. The brakes are lined with hard wood and are adjustable for wear. The clutches are easily adjustable for wear by means of the nut at the end of the main shaft. They are worked by means of hand levers of the signal type and a small catch working on a rack, this allowing for slight wear of the clutch. The two brake levers, two clutch levers, and controller handle are all within easy reach of one man without his moving.

The bed is built up with steel girders, and is so arranged that the middle and one outside girder can be removed, and the main shaft, complete with drums, brake sheaves, and clutches, lowered down on to the track for repairs.

Each plant is supplied with an air-tight three-pole fuse box, and also an air-tight three-pole quick-break switch.

Fig. 2 shows a double-track haulage gear, as supplied by Messrs. Clarke, Chapman & Co., to Messrs. Witty and Wyatt, of Bilbao, for their Dicidio Pit; the unbalanced load being 1½ tons at 200ft. per minute. This gear is arranged for working a double track with one cage ascending and one descending.

The motor is 30b.h.p. three-phase, and drives the drum through two pairs of spur wheels. The main wheel is bolted to the barrel flange and is cast steel; the main pinion is of cast steel, both being machine moulded. The motor pinion is raw hide, and gears with a cast-iron machine-cut spur wheel. The break, which is very powerful, is of the post type, and is put on by means of a foot pedal, which is close to the controller. The controller is of the tramway type, reversing and speed regulating.

Fig. 3 shows a typical double-drum haulage for underground work, made by the Uskside Engineering Co., Newport, Mon. It is entirely self-contained on a steel-plate bed plate, and when fitted with built-up steel drums and steel gearing is practically unbreakable and therefore specially suited for the rough usage generally experienced in mines. The motor is 150h.p., running at 500r.p.m.; the drums give a speed to the rope of six miles per hour. Each drum is provided with a powerful brake and runs loose on the shaft, being actuated by means of a steel jaw clutch, or in some cases a band friction clutch. Motors for haulage work require to be of specially strong design mechanically, and capable of withstanding heavy overloads. For alternating-current systems wound rotors with slip rings must be provided in order to admit of speed regulation when absolutely necessary on bad curves, &c., on the roads, but in order to obtain the highest efficiency the attendants must be carefully instructed to run in the short-circuited position as much as possible. Perhaps the most important part of an electric haulage equipment is the controller, which is in constant use. Many types have been tried more or less successfully, and the tendency is to revert to the earlier form of liquid controller for small and medium-size motors, owing to its simplicity. For heavier work, however, the tramway type with well-designed metallic contacts is in general favour. Except for small powers, automatic cut-out switches should be fitted in place of fuses, although there is no harm in having the latter somewhere in the circuit as an additional precaution.

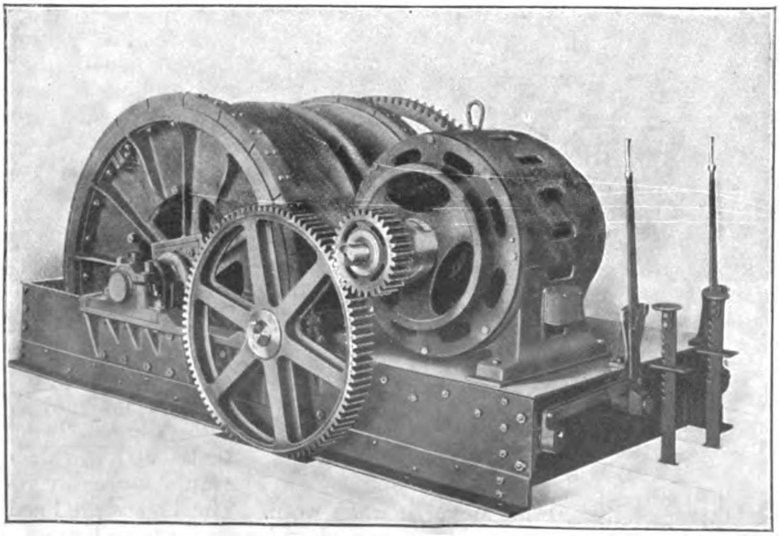
Fig. 3. Uskside 150h p. Double-drum Electric Haulage.

The Uskside Engineering Company have made and supplied a large number of these heavy power haulages, chiefly for South Wales collieries. About two and a half years ago Messrs. D. Davies & Sons, Ferndale, decided to adopt electricity for their haulages and have already a number of 100h.p. and of 200h.p. sizes working with single-reduction gearing and slow-speed motors running at 187r.p.m. The motors appear very large for their rating, but this is due to the slow speed and the fact that they are totally enclosed. They are fixed on independent foundations with a flexible coupling connecting them to the haulage gears. The gearing is machine-moulded steel; the drums are built up with steel sides and run loose on the shaft, each being worked with a steel jaw clutch. The brakes are very powerful and are fitted with iron wearing blocks owing to the danger of wood firing. These haulages have already done good work and have clearly demonstrated the great advantage of electric as against steam-operated engines. At the Lewis Merthyr colliery near Pontypridd two 150h.p. double-drum gears have been working for some time with equally satisfactory results.

Fig. 4 shows a three-drum haulage driven with a Westinghouse three-phase motor supplied to the Powell Duffryn Steam Coal Company for their new Bargoed colliery. The motor is of 200h.p. and runs at 480r.p.m. It is direct-coupled through double-reduction steel gearing proportioned for a rope speed of five miles per hour on the mean diameter of the drums. Each drum is loose on the shaft with steel jaw clutch to work it. The drums are heavily constructed of steel plates, channels and angles, and are fitted with powerful pillar brakes. They are 4ft. in diameter, 1ft. 9in. wide, and 1ft. 6in. deep.

At the United National Colliery, Risca, a number of "Uskside" double-drum haulages are working, the largest being of 250h.p. equipped with a high-speed motor and steel double-reduction gearing. A Bruce-Peebles three-phase motor is mounted on an extension of the bedplate. The motor speed is 490r.p.m. A feature of this plant is the liquid controller adopted, a recent and patented invention of Messrs. Bruce Peebles & Co., Ltd.

Fig. 6 shows a 100h.p. Westinghouse variable-speed slip-ring induction motor driving a main-and-tail haulage-gear. As the latter service is intermittent, with fairly long stops, it is necessary to employ a reliable motor which possesses a starting torque sufficiently large to overcome quickly and easily the great initial inertia of the load. On such service the above type of motor is

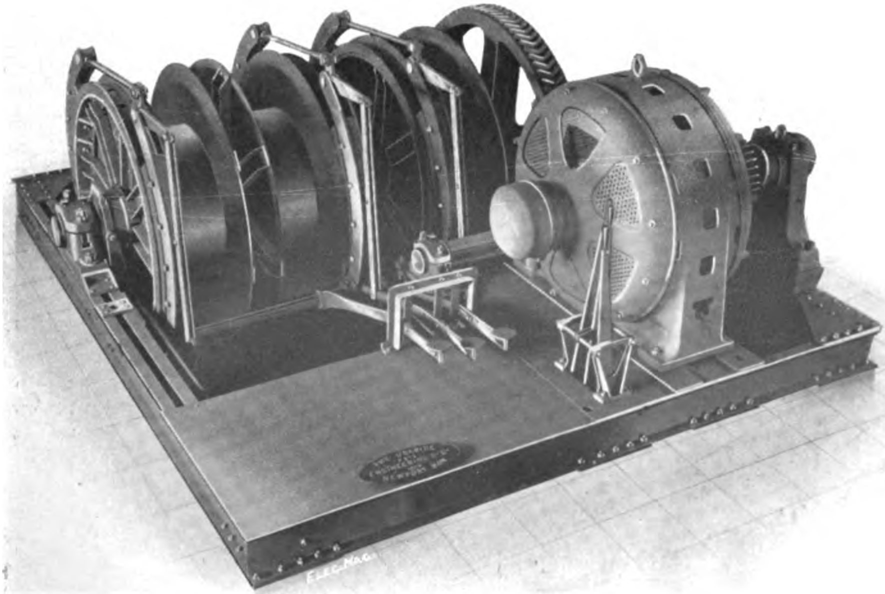

FIG. 4. 200H.P. THREE-PHASE WESTINGHOUSE-USKSIDE THREE-DRUM HAULAGE—POWELL DUFFRYN STEAM COAL CO.

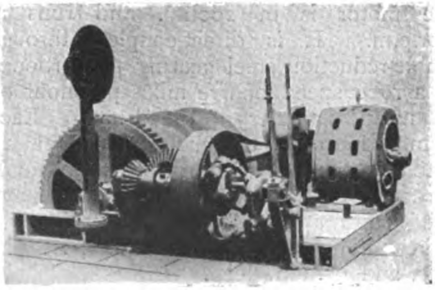

FIG. 5.

specially suitable, since it is capable of giving a starting torque practically equal to twice the full-load torque. Further the momentary overload which the motor will safely carry is 100 per cent. above its normal h.p. rating. The rotating part or rotor of the motor is wound with insulated coils which are connected through slip rings to an external resistance in series. The regulation of the motor speed is effected by cutting resistance in or out of the rotor circuit by means of the controller shown in the view. This apparatus is of the reversing drum or tramway type and has renewable arcing tips fitted to the current-breaking contacts.

An unusual form is shown in Fig. 5; the machine comprises two drums, and, as it was supplied for sinking as well as for ordinary winding purposes, the right-hand one is loose on its shaft, but can be thrown into gear with the other by a claw clutch at the right side of the machine. The diameter of each drum is 4ft. and the total load dealt with is one ton at a speed of 600ft. per minute. The drums are driven by a cross-shaft, having a machine-cut bevel wheel in gear with two other similar bevels mounted on a countershaft, on which is also a double-claw clutch for throwing one or other of them into gear to effect the reversal of direction of the drums. On the countershaft is also mounted one of Mather & Platt's friction clutches, the pulley of which is driven by belt from the motor pulley; a jockey-pulley being provided on account of the shortness of the drive. The

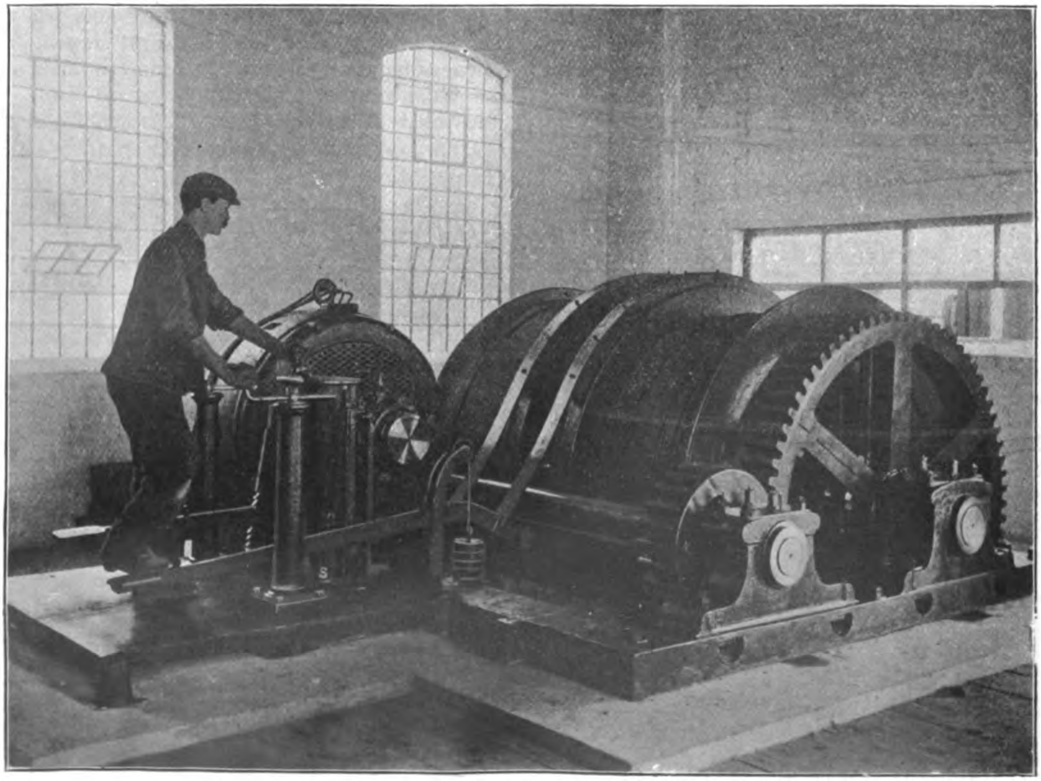

FIG 6. 100H.P. WESTINGHOUSE THREE-PHASE MAIN-AND-TAIL HAULAGE GEAR.

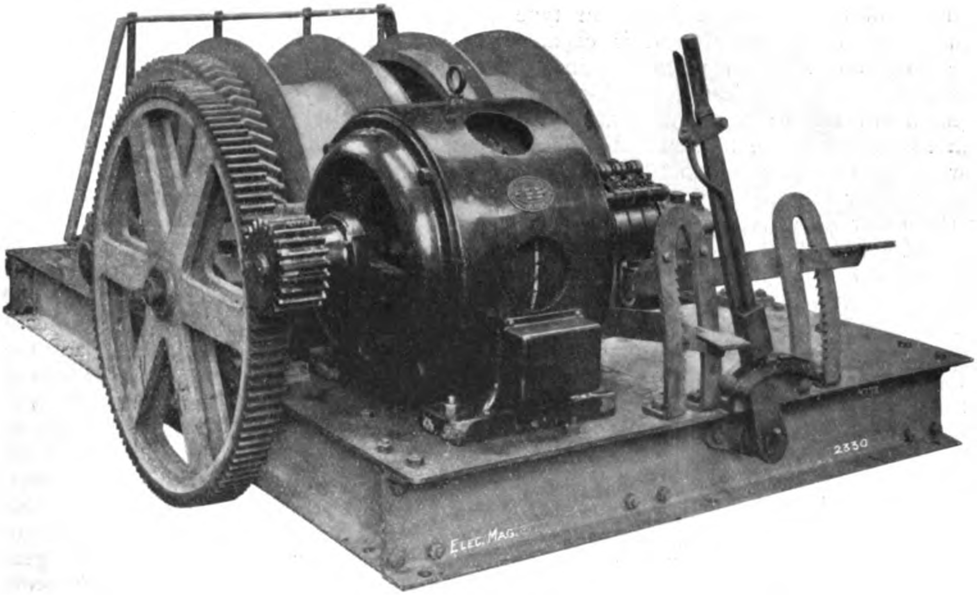

FIG. 7. GENERAL ELECTRIC CO.'S 15H.P. THREE-PHASE DOUBLE-DRUM HAULAGE, ASHINGTON COLLIERY.

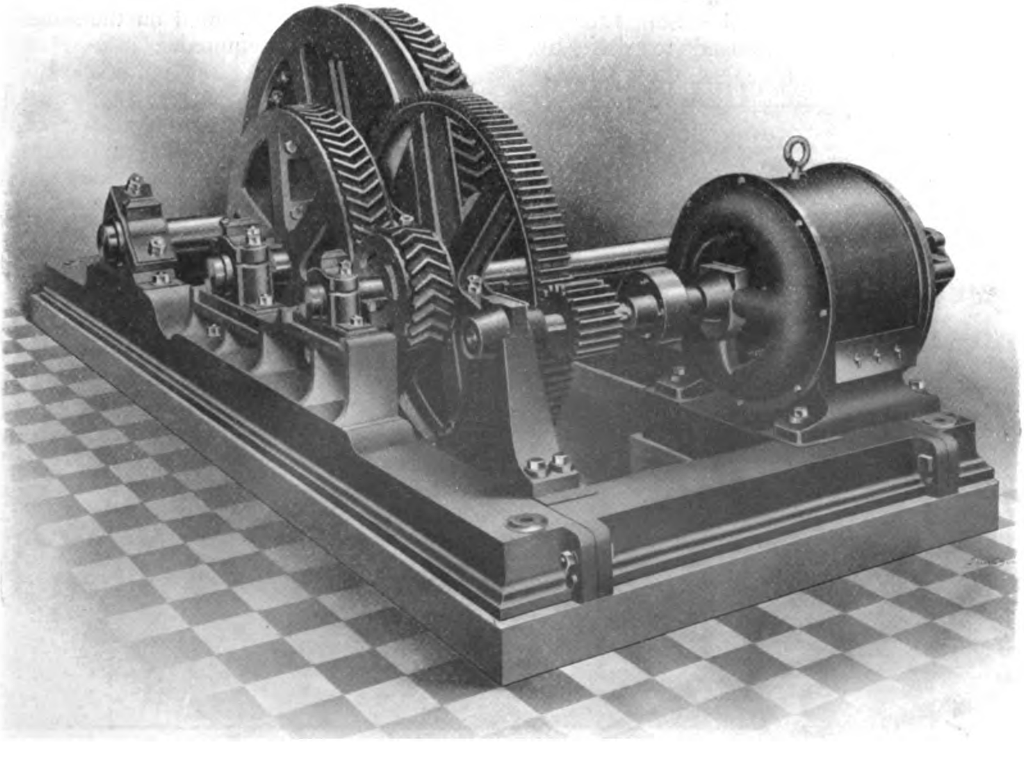

FIG. 8. 35H.P. ENDLESS ROPE HAULAGE. CORLETT ELECTRICAL ENGINEERING COMPANY, LTD.

motor is of the two-phase induction type with short-circuited rotor, and is capable of giving out 40b.h.p. when running at 750r.p.m. No complicated switch-gear is required with this arrangement, as the motor is first started with the friction clutch out of gear, and therefore without load; after throwing over the double-claw clutch to one or the other side, according as to whether the load has to be hoisted or lowered, the friction clutch is put into gear, and the motor gradually takes up the load.

The two haulage gears shown by Figs. 8 and 9 are of the endless rope type; in both cases the motors drive through a flexible coupling. In the latter, the motor is of 40b.h.p. capacity and the gear is fitted with two rope wheels, each of which is thrown into gear by friction clutches. In the other case (Fig. 8) the motor is of 35b.h.p. of the three-phase type with slip-ring rotor. These two equipments are both by the Corlett Electrical Company, Ltd., and a comparison of the two reveals a difference in the mechanical detail of the drives interesting to the practical engineer.

The haulage gear illustrated in Fig. 10 is made by Messrs. W. Neill & Son, Ltd., of St. Helens. It is arranged to drive by cotton ropes, from a 50b.h.p. motor placed at a suitable distance. The bedplate is made up of steel joists strongly bolted together with suitable sole plates to carry the shaft pedestals. The drums are arranged for main-and-tail haulage and run loose on shaft. They are driven by a friction clutch of the expanding type, put into gear by levers, actuating right-hand and left-hand threaded screws. The drum sides are of cast iron with steel plate lagging. The gear wheels are of cast iron with machine-moulded helical teeth. The whole construction is of heavy proportions for the working load; the shaft bearings are large in diameter and of good length, to give ample wearing surface. The foot-brakes and hand-wheels for operating the clutch are mounted together in the centre of the footplate within easy reach of the driver. Messrs. Neill & Son also make various types of haulage gears up to any capacity. Although the particular gear illustrated is arranged for the motor being on a separate foundation and driving by ropes, this form is somewhat exceptional, and the makers of course supply also the usual form of all-geared haulage with the motor and controller mounted on the same base as the gear, if required.

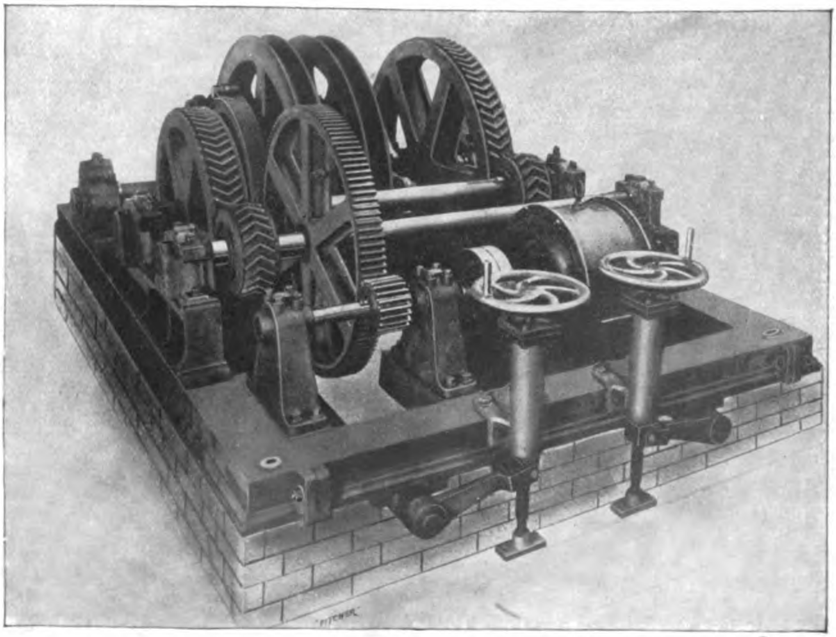

FIG. 9. 40H.P. TWO-WHEEL ENDLESS ROPE HAULAGE. CORLETT COMPANY, LTD.

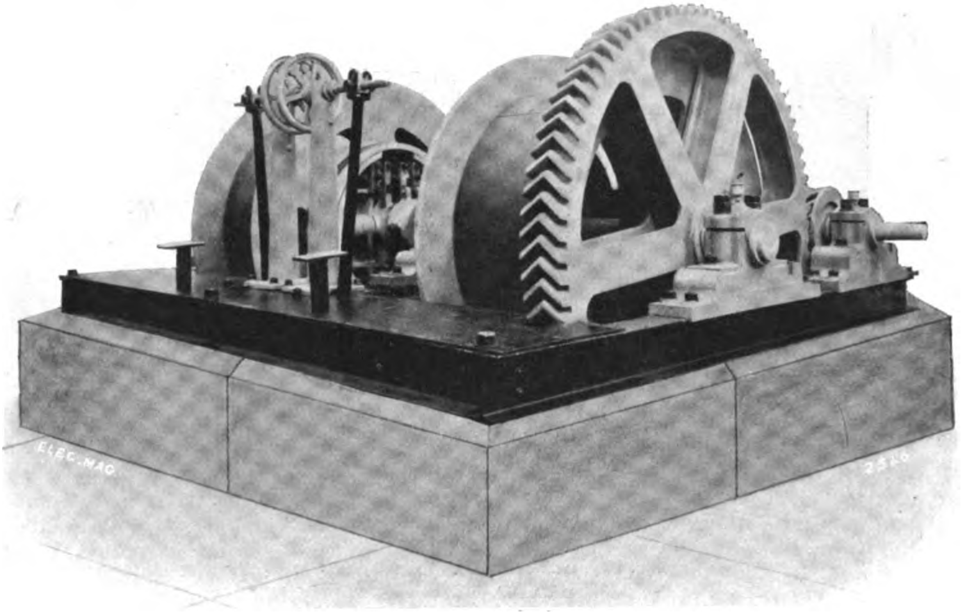

FIG. 10. MAIN-AND-TAIL HAULAGE; ROPE DRIVEN BY 50H.P. MOTOR. W. NEILL & SON, LTD.

Horses have long since left the main roads and they are now gradually disappearing altogether from many of the mines. Even for "in-bye" haulage small electrically-driven machines are being used and showing great economies. It is for such work that the inherent electrical advantage of ready and efficient transmission is most pronounced. It is also here that the compact electric motor appears to advantage: allowing of the design of small yet powerful and portable electric haulages.

Two examples of haulage gears specially designed for this class of work are illustrated herewith. Fig. 11 shows the "Uskside" portable haulage set, of which the width is less than 42in. and the height from the rails is only 50in. The motor is of 25h.p. and the gearing gives a speed to the ropes, which are for main-and-tail working, of 4½ miles per hour. Although of small dimensions the power is considerable, and on an incline of 3in. to the yard a dead load of 10 tons can be easily hauled. The Tredegar Iron & Coal Company were the

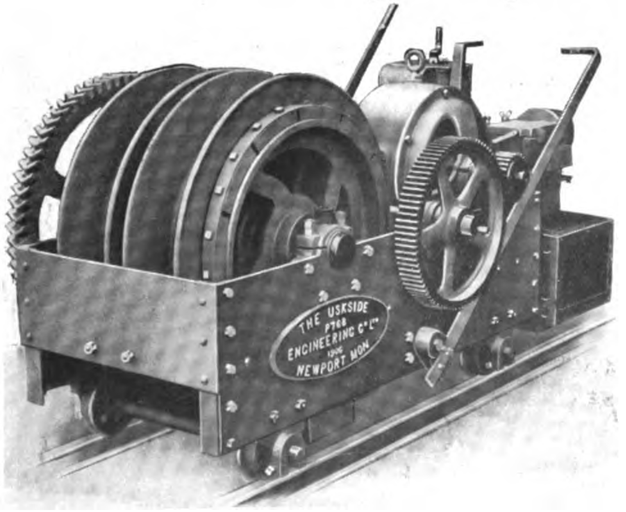

FIG. 11. USKSIDE 25H.P. PORTABLE ELECTRIC HAULAGE.

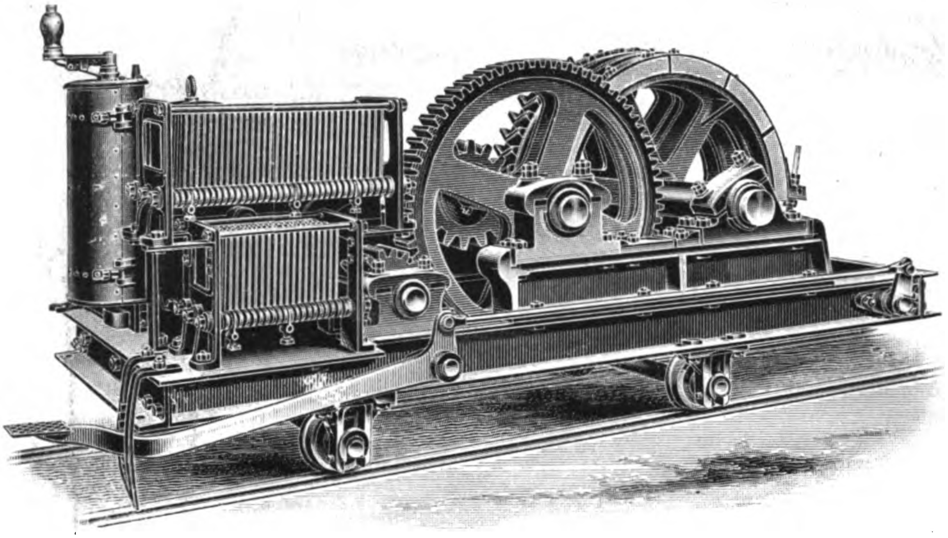

FIG. 12. 30H.P. PORTABLE HAULAGE. JOHN DAVIS & SON (DERBY), LTD.

first to adopt these haulages and have recently decided to install others. A special feature to be noticed is the compact nature of the whole of the electrical equipment, which is entirely carried on the haulage. The motors are for low-tension three-phase current provided with slip rings enclosed in a flame-tight case. The tramway type controller works in oil, as does also the triple-pole switch and fuses which are combined

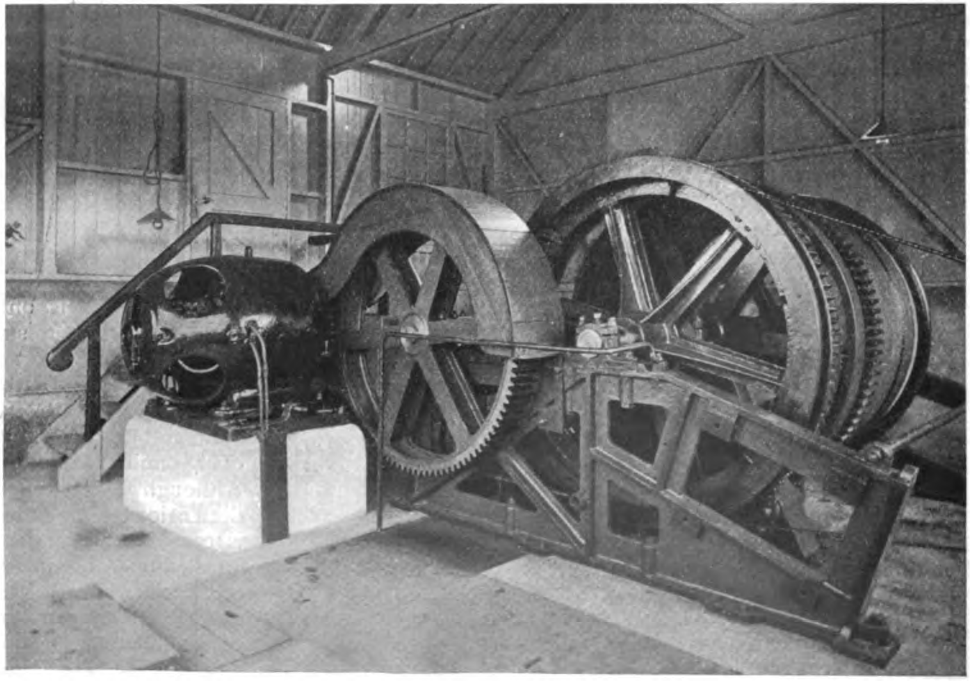

FIG. 13. 60H.P. SIEMENS HAULAGE SET OPERATING AERIAL ROPEWAY SYSTEM.

in one strong iron casing with the ammeter. A strongly constructed special grid resistance is attached, and this is carefully protected from all extraneous matter.

The other portable haulage gear, illustrated in Fig. 12, is by John Davis & Son (Derby), Ltd., who have supplied a number for service in the new colliery of the Bolsover Coal Company, Mansfield. In this case the power equipment consists of a 30b.h.p. three-phase motor fitted with enclosed slip rings and having a tramway type controller.

In Fig. 13 is shown the electrical end of a haulage system which, while not in this particular instance used for colliery purposes, will be of interest to colliery engineers as dealing with aerial rope traction or telpherage—a principle of transportation quite frequently used in colliery practice in this country. This equipment is installed at the Guernsey Quarry of Messrs. William Griffiths & Co., Ltd. The "Blondin" is used for lifting granite spalls from the quarry. This is done by raising and lowering the carts, slung by chains on the travelling carriage. Each load raised weighs from 30 to 32cwt. nett, and the gross load is equal to about 50cwt.

The average quantity of granite spalls dealt with each day varies between 130 and 150 tons. The largest quantity which has been raised in one day is 205 tons.

These spalls are conveyed direct to the stone-breaking plant, which is also driven by electricity, and is capable of dealing with about 600 tons per day.

The ropeway system is driven by a 60h.p. Siemens motor on a 420-volt direct-current circuit. The controller, levers for operating the clutches, and the break gear are all arranged so that the driver has a full view of the quarry, thus saving time in working, and avoiding the uncertainty of the method of telegraphing signals to the winding house. The span of the "Blondin" is 490ft. and the drop from the cable 150ft.

* * *

Electric Locomotives.

MINE traction by locomotive as distinct from "haulage," which in colliery work may be taken as signifying a fixed power machine and rope transmission, has made practically no progress in this country, and although a number of our leading electrical firms include electric mining locomotives in their lists, whatever demand they have for these engines is for abroad. There are indeed certain drawbacks which would seem to still delay development in this direction; the two chief are: that direct current with risk of sparking impossible to guard against is at present the only fully developed means of traction; and that bare conductors and an earthed return are practically essential.

Yet where mines are free from fire damp and the roads have no excessive gradients and are of fair size, there is no doubt that traction by locomotive has distinct advantages over rope haulage. It is not necessary here to describe the electric locomotive, for, after all, surface work and mining work are identical in principle, the difference only being in reality a matter of size and dimensions of the locomotives.

There is, however, one system of electric traction in mines which will be of particular interest to readers—if only by reason of the fact that it is a novel, and, it is claimed, very successful American arrangement recently introduced into this country and now being exploited by the newly formed Goodman Manufacturing Company, Ltd., of Cardiff.

The system consists essentially of two elements—a stationary third rail and a powerful locomotive or pulling machine working in it, on a modification of the rack principle. The chief advantage is its positive working and practical use with light track rails and on heavy gradients.

The combined third and traction rail is an exceedingly simple and powerful device. This rail transmits the current to the locomotive, but is so constructed that it is impossible for men and animals to come in accidental contact with it. It is claimed that this third rail is as easily laid as the regular track and can be extended as readily. Strength in its construction is an important feature, as against this rail is exerted all the pulling power of the locomotive. It is so built that heavy falls of roof will not injure it.

The system consists primarily of an iron rack anchored to the ties between the track rails, and an electric locomotive provided

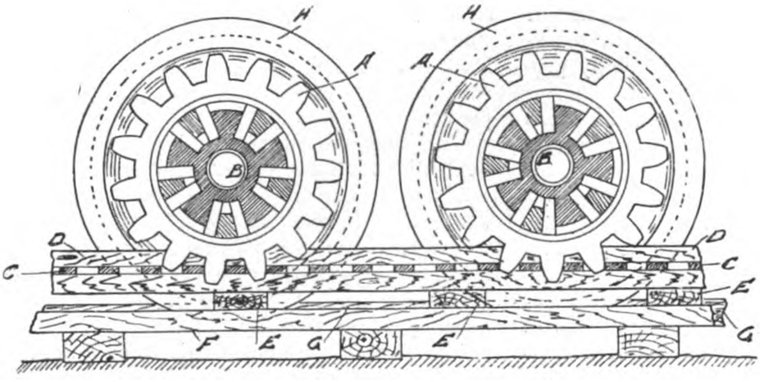

Fig. 1.

with sprocket wheels, which run in this rack (Fig. 1). The rack is used in some cases as a conductor, and then takes the place of a trolley wire; in other cases it is used only for the mechanical purpose of propelling the locomotive.

Two classes of locomotives are made. One of these is a plain rack rail locomotive designed to operate only where the rack rail is laid; the other is a combination rack rail and traction locomotive, and is designed to run either as a rack rail locomotive or as a traction locomotive. These locomotives are built in units of 80h.p., styled type "B" machines, and of 100h.p., styled type "F" machines, and when greater horse-power is required, the "F" units are run in tandem, thus making locomotives of 200h.p.

The plain rack rail locomotive consists of a continuous-current series-wound motor mounted on a four-wheel truck. A sprocket wheel is mounted on each axle, and revolves loosely upon it, a train of gearing connecting the motor armature with the sprocket wheels. The track wheels serve only to carry the weight of the locomotive, and this weight is made no greater than is necessary to provide mechanical strength of parts, thus eliminating the great amount of dead weight carried by traction locomotives. The sprocket wheels and gears are free to move along the axle one inch either way from a central position, but are held in the central position by springs. This flexibility allows for irregularities in the relative positions of the track rails and the rack.

The combination locomotives differ from the plain locomotives in that their track wheels, as well as the sprocket wheels, are driven by the motor, and they are equipped with sanding devices. When the rack is used as a conductor in place of the trolley wire the rims of the sprocket wheels are insulated from the driving hub by wood blocks, these being first treated to prevent absorption of moisture.

The rack rail, shown in section in Fig. 1, consists of bar iron ⅝in. thick, and varying in width from 4in. to 4½in. This is perforated with holes 1⅝in. square, and is made up in straight pieces 16ft. long. These 16ft. pieces are built into a continuous rail by the use of fishplates in a manner similar to that used in ordinary track construction.

This rack is laid between the track rails, sufficiently higher than the latter to permit the points of the sprocket teeth passing over them. In those cases where it is to serve as a conductor in place of a trolley wire, it is supported on wooden stringers, and protected with a wooden covering. This wooden portion of the rack rail structure consists of four parts: first—a bottom stringer which is 6¾in. wide, and is spiked to the ties; second—spacing blocks which are 6¾in. long by 4in. wide, and are spiked to the stringer at 18in. centres; third—the

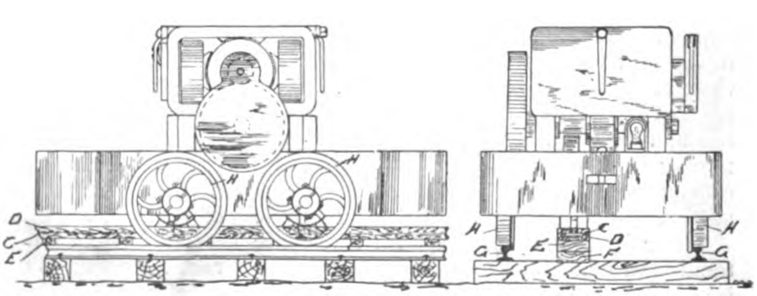

Fig. 2.

lower covering strips which are spiked to the spacing blocks, and have a recess provided in their upper surface to receive the rack; and fourth—the upper covering strips which are spiked and bolted to the lower strips, and are identical in cross section with them, and which serve to hold the rack down and also protect it against accidental short circuits. In cases where the rack is used for mechanical purposes only, the bar is rolled with a bevel edge on each side, and is supported on malleable cast-iron chairs, which clamp it to a bottom stringer. The bottom stringer is similar to that used for the insulated rack, but is thicker and narrower. The iron chairs are spaced 12in. centres, and are used in pairs, the pair being held together by a bolt which serves to clamp the chairs on to the rack and the stringer.

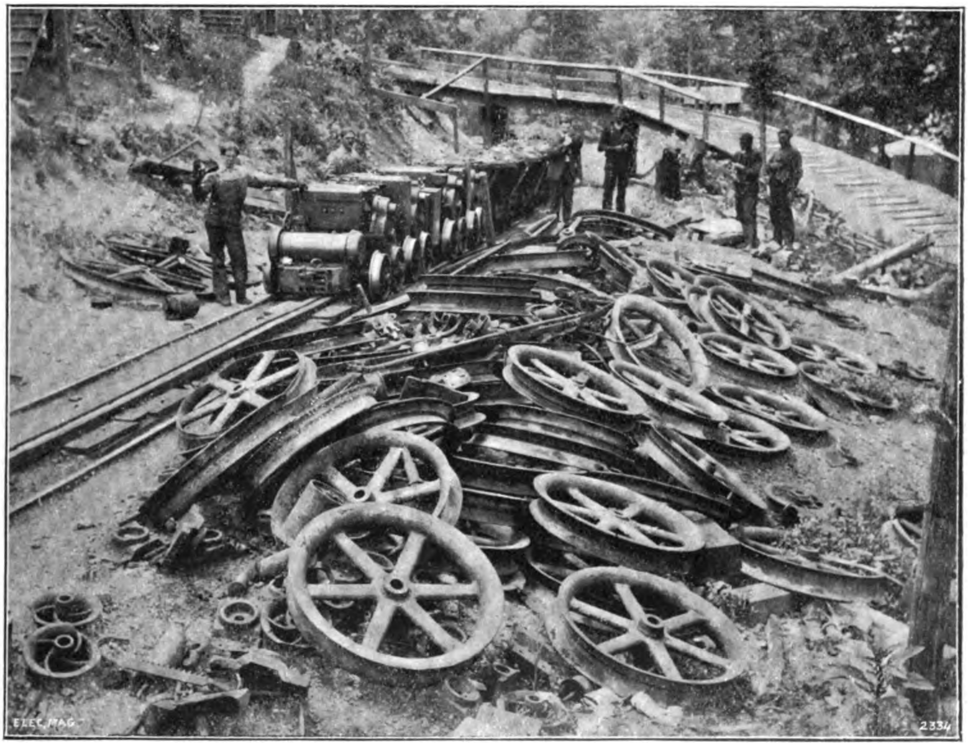

FIG. 3. INSTALLATION OF GOODMAN RACK RAIL SYSTEM OF MINE TRACTION.

At junctions and crossings the rack is cut to permit of the track rail crossing it. At such places suitable fittings are provided to connect together the ends of the rack by an iron bar passing under the transfer track rail. In cases where it is necessary to cut out more than 26¾in. of the rack, a throw rail, or rack switch, is provided. When the rack is used as a conductor in place of a trolley wire, an insulated bonding cable is used to connect together the ends of the rack at such breaks.

When the locomotive is a combination machine, the rack is discontinuous, being only used on the grades. These discontinuous pieces of rack terminate at each end in an "approach," which is a heavy steel casting bolted securely to the rack, and so shaped that it forces the sprockets to mesh properly with the rack.

The rack rail system of haulage has been extensively installed in coal mines, and we understand there is now in daily service apparatus aggregating upwards of 15,000h.p. It was put on the market in the United States about six years ago. Its progress at first was slow, but the experimental period is long since passed, and this method of surmounting grades in coal mines is now thoroughly established. At the present moment the Goodman Company of Cardiff are carrying out a number of these installations in the United Kingdom.

Two interesting views of the system as installed are shown in Figs. 3 and 4. In the former are to be seen a heap of haulage and guide pulleys thrown out of service by the two locomotives; the other shows the heavy grades which are negotiated by these locomotives.

Another very interesting machine manufactured by the Goodman Company is what is termed a "gathering" locomotive, that is to say a locomotive which carries as part of its general outfit a reel of twin cable having two hooks on the end; one of these is attached to the trolley line and the other to the rail. This enables the locomotive to run into the various galleries and working places in a mine without the necessity of erecting trolley wire everywhere.

The common tendency heretofore in the development of electric mining locomotives for use in gathering service has been to adapt standard designs, principally by addition of a cable reel. Efforts in this direction have involved use of the standard two-motor type of locomotive, having heavy side frames and fitted with two independent motors carried on the axles. This type of locomotive cannot be built sufficiently compact to fulfil properly the usual requirements of gathering work. For narrow gauges, the frame must be outside the wheels. Furthermore, the overall length is necessarily excessive, because of the construction required for the accommodation of two motors. Other matters, including length of wheel base, general overall dimensions, flexibility for operation over poor tracks, &c., combine to render difficult if not thoroughly impracticable the satisfactory adaptation of a standard type of locomotive to the conditions of gathering service.

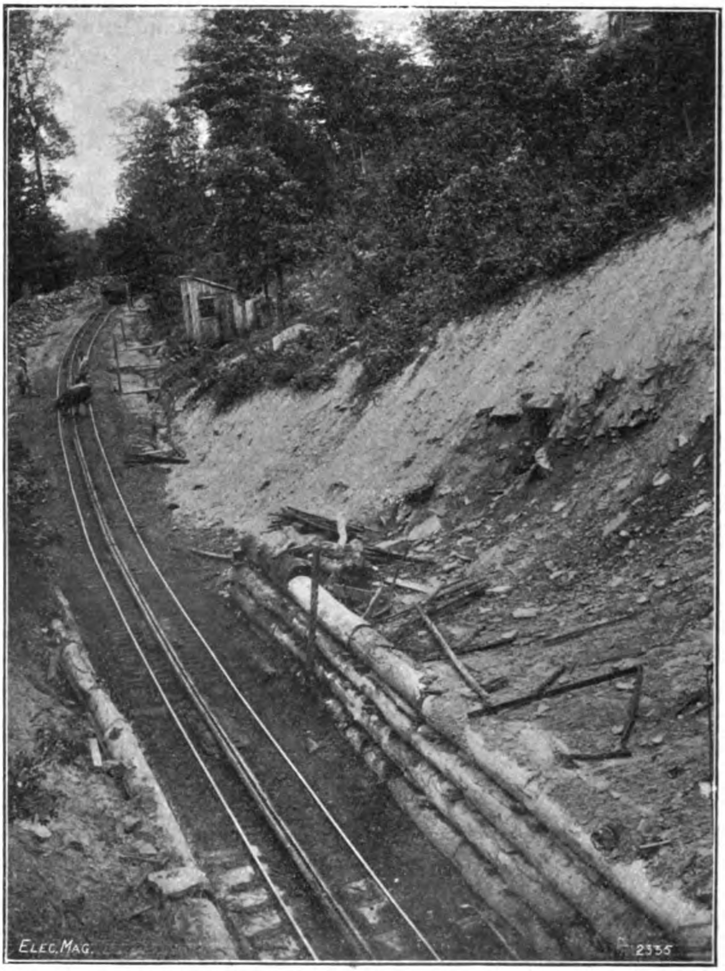

FIG. 4. INSTALLATION OF GOODMAN RACK TRACTION SYSTEM. A HEAVY GRADIENT.

The illustration Fig. 5 shows the new Goodman gathering locomotive as designed for this specific purpose. It is claimed that this locomotive is of such size and weight as will enable it to go wherever a mine-car or

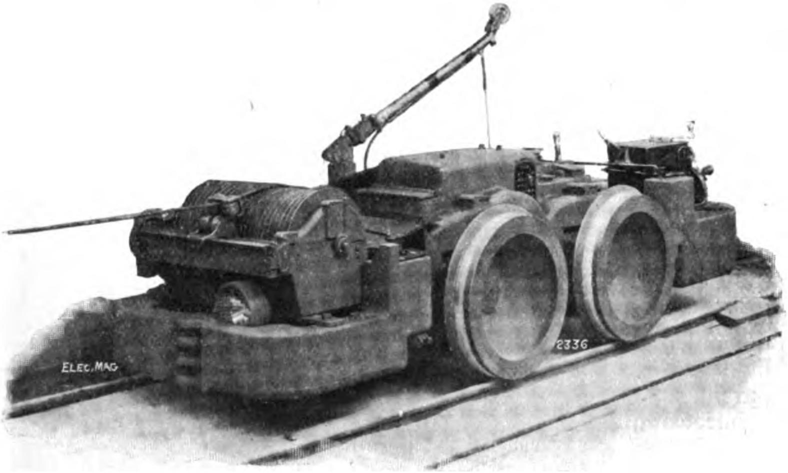

Fig 5. Goodman Gathering Locomotive.

tub can go, and with equal facility. The electric cable-reel is a separate piece of mechanism, operating independently of the locomotive gearing—a feature of great importance for successful working. The wheel-base of the locomotive is very short and the wheels themselves are small. Only one motor is used, and this is built in as a unit with the locomotive frame. The axles are fitted with springs so as to afford a flexible wheel-base which will enable the locomotive to follow a rough track even more easily than will the mine-car itself. By gearing of special design and arrangement, the armature of this single motor, built into the frame, is in driving connection with both axles, yet without interfering with the flexibility of wheel-base. Such a gathering locomotive will haul a mine-car, with short hitch, around room-neck curves of small radius. The height of the locomotive from rails to top of frame is 32½in. and the overall length is 7ft. 9in.

The illustrations Figs. 6 and 7 show the general form of two mining types of electric locomotives as built by Messrs. Mather & Platt. The former locomotive was supplied for shunting operations in a mine in Sweden. It is fitted with a double-collector arch, for taking the current at a pressure of 300 volts from an overhead conductor carried 16ft. above the rail level to avoid buildings; the rails form the return circuit. There is one direct-current motor with a double-wound armature, the driving being effected through spur gear with a speed reduction of ten to one. The general dimensions of the locomotive are: length, 9ft. 4in.; width, 6ft. 10in.; height, 9ft. 8in.; wheel-base, 4ft. 6in.; gauge, 4ft. 8½in. It has a total weight of 6 tons 3cwt., and gives a draw-bar

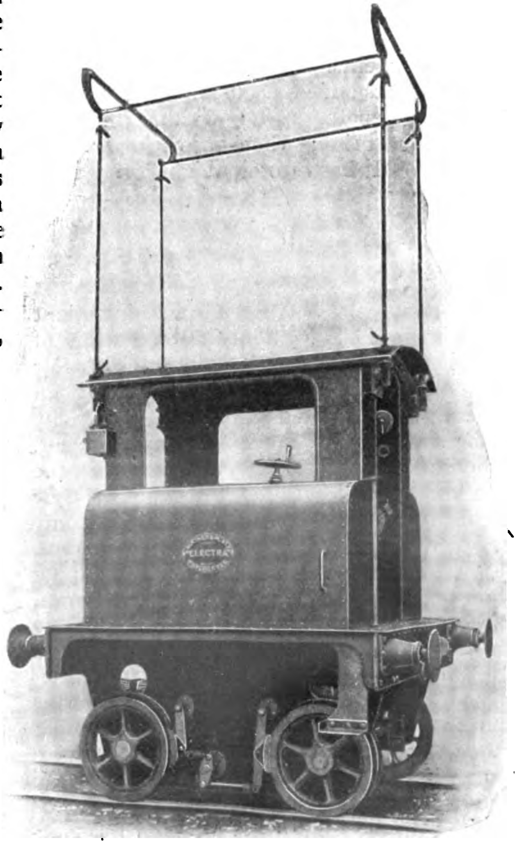

Fig. 6. Shunting Locomotive. Mather & Platt, Ltd.

pull of 2100lb. at 4½ miles per hour.

The locomotive illustrated in Fig. 7 is for work underground, in a tunnel 5½ft. high and 5¼ft. wide. The frame is of steel, as are the axles and tyres, the wheel bodies being of cast iron. There are two entirely-enclosed direct-current motors mounted one on each axle, being partly borne on the axle and partly by springs attached to the underframe. The drive is by single-reduction gear. The current, at a pressure of 500 volts, is collected from an overhead conductor by an ordinary trolley arm, the return being by the rails. The locomotive is fitted with a series parallel controller and with an electric brake, as well as with a screw hand brake and the customary lightning arresters and instruments. The outside measurements of the locomotive are: Length, 12ft.; width, 4ft. 5in.; height, 4ft. 11in.; wheel-base 4ft.; gauge, 2ft. 5½in. It has a total weight of 4 tons and is capable of developing a draw-bar pull of 1100lb. at a speed of 10 miles per hour.

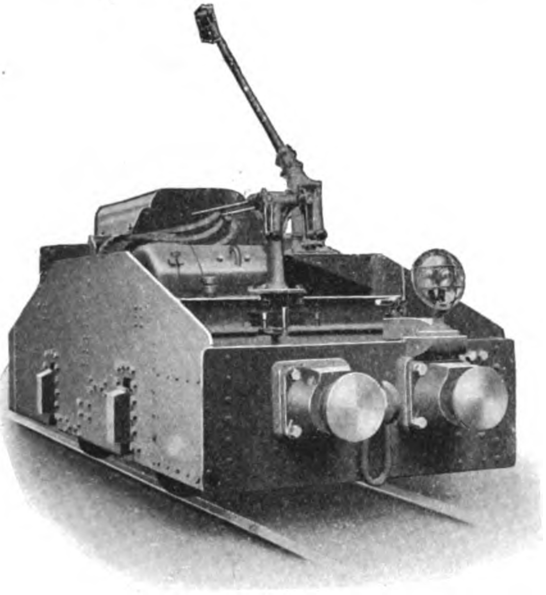

FIG. 7. UNDERGROUND MINING LOCOMOTIVE. MATHER & PLATT, LTD.

Electric Pumping.

PROBABLY the driving of pumping plant is the most widely adopted form of electric power as applied in mines. For this class of service it has long been generally acknowledged that electricity is far superior to any other power agent. Whether the pumping sets are of the smallest or largest sizes and whether they are far in-bye or at the shaft their economy and general advantages are most apparent.

The electric motors for mine pumping duties are as a rule of standard types, direct-current and alternate-current, suitably protected and operating at constant speed. In some cases where the pump is started up against a full column of water, special heavy current motor starters are used; in other cases for the direct driving of centrifugal pumps, motors of higher speeds than normal are necessary. Yet it may be taken as typical of the universal adoption of electricity for pumping that all the leading pump makers have made it their standard practice to design and build as stock products machines specifically intended for electric driving. It is to modifications in pump construction that one must turn for novelties in electric pumping matters. Various forms of geared ram-pumps and those of the centrifugal or turbine class are the only kinds now bought for mining service. In the case of the former type the tendency of designers has been towards increased speeds as being best suited for the electric motor and of course reducing the dimensions and weights. The restraining factor in this development has been the valve arrangements, but many ingenious solutions of this difficulty are now on the market and making headway. The selection of the best type and make of pump for any particular service requires great care. The nature of load—that is, the proportion of volume to pressure—will, other conditions being common, often decide whether a reciprocating or a centrifugal pump shall be used. With the latter type the conditions are best when the quantity in gallons per minute is about equal to the number of feet head ; thus a turbine pump of the Worthington type designed for 500 gallons per minute against 500ft. head has an efficiency of 72 per cent. or more, whereas a similar pump designed for 50 gallons per minute against 500ft. head has only an efficiency of 60 per cent. Where the head is greatly in excess of the quantity, ram-pumps would probably be best for reasons of economy.

The turbine pump, moreover, is not very suitable for variable duty ; it is essentially a velocity machine designed for operation at one particular speed, and any lowering in its speed beyond the limits of about 10 per cent. will render it inoperative ; to reduce the head of a turbine pump is to increase its output at a constant speed. Comparing the turbine with the reciprocating pump, it will be seen that the latter handles a certain definite volume of water per stroke or per revolution, and that therefore its output is constant at any speed irrespective of the head, the higher limit of the latter only being reached with the mechanical parts of the plant and the power of the motor. The output of a reciprocating pump is directly proportional to its speed, and is not dependent upon the head worked against.

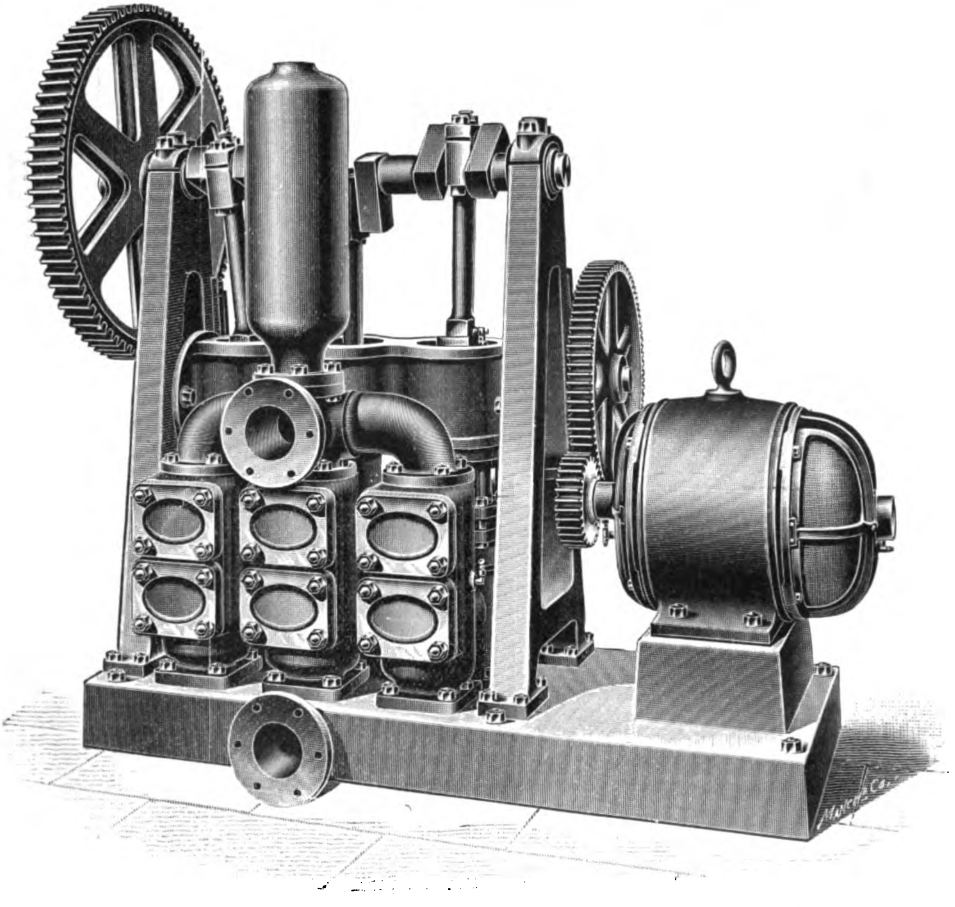

FIG. 1. ELECTRIC THREE-THROW VERTICAL PUMPING SET. FRANK PEARN & CO., LTD.

Reciprocating pumps are better for considerable suction lifts than are turbine pumps ; where the latter are installed, therefore, they must be set close down to the water.

The quality of the water enters into this question to a very important degree. Where there is a good deal of sharp grit in suspension, turbine pumps are at a disadvantage owing to the rapid scoring of the internal portions of

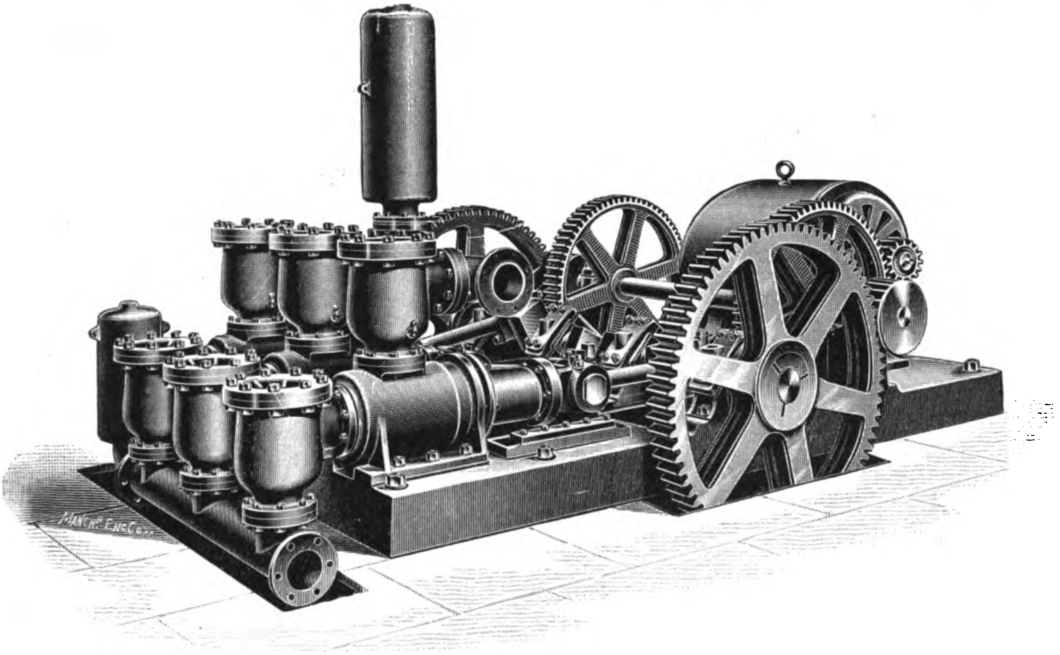
MANCHR. ENG. CO.

FIG. 2. ELECTRIC PUMP, THREE-THROW HORIZONTAL TYPE (PEARN).

the pump, thus quickly reducing the efficiency and destroying comparatively expensive parts; when used with waters of this class it is of course desirable to work with low water velocities, whatever type of pump is used. Then again it often occurs that mine water is corrosive, having large percentages of sulphuric acid; in such cases alloys of special mixtures are sometimes desirable for the internal parts, but it is particularly important that those parts where the corrosion is greatest shall be simple, small, and inexpensive for renewal. The chemical action with a turbine pump will be greatest at the edges of the impellers or vanes; in the reciprocating pumps, at the valves and seatings. The latter are the less costly to maintain.

The great advantage of the turbine pumping set is that it is very much cheaper than any reciprocating type; not only is this true of the pump alone, but the electrical equipment is usually less, owing to high speeds and direct coupling being common.

There are, of course, many other points of comparison of mechanism and operating

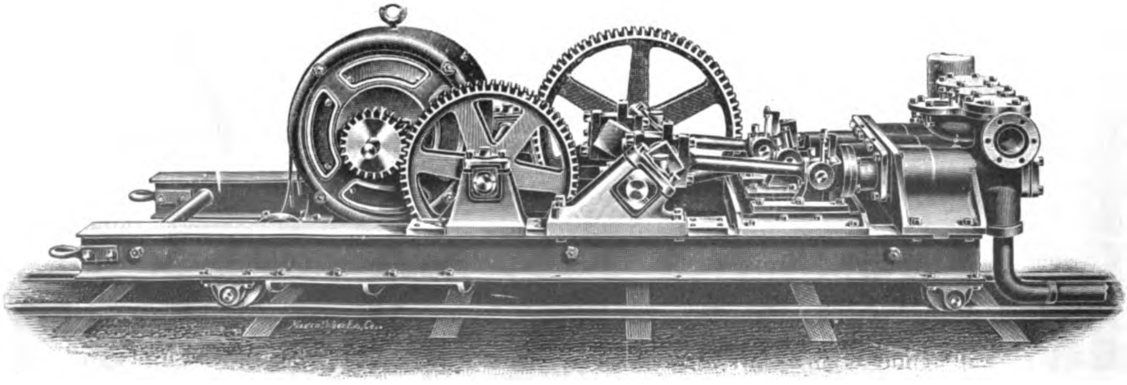

FIG. 3. PORTABLE THREE-THROW ELECTRIC PUMP (PEARN).

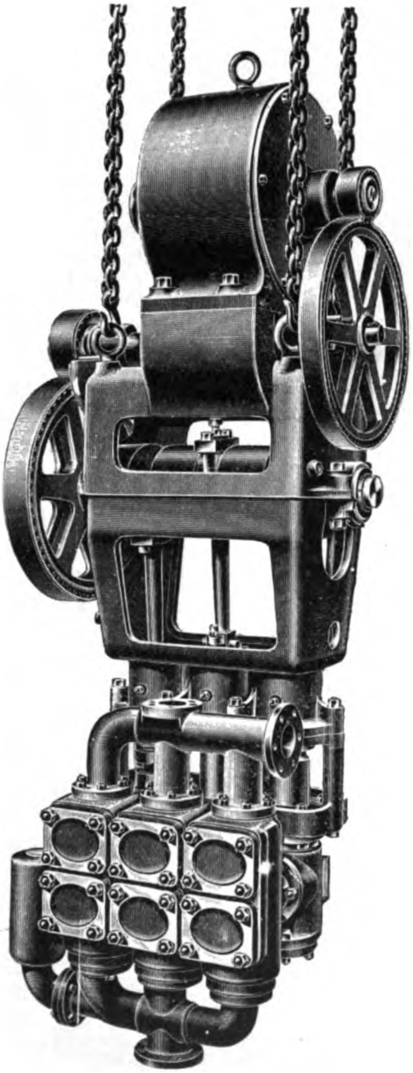

FIG. 4. ELECTRIC SINKING PUMP (PEARN).

conditions not touched upon, but sufficient has been said to show that reciprocating pumps of high and medium speeds, and turbine pumps, have each their particular sphere of utility, and all are likely to remain in constant demand.

The several illustrations indicate the variety of electric pumping sets which are in most frequent use. It will be noticed that three-throw pumps, both vertical and horizontal, are assembled with the driving motor on one common bed-plate, and that the driving is through double-reduction spur-gearing. A novelty in the way of gearing will be noticed in the illustration Fig. 2: this method of dividing the drive into two similar sets of gears at each end of the shafts is used by Messrs. Pearn for some of their largest-sized pumps.

The three-throw sinking pump, Fig. 4, is interesting as showing how extremely adaptable the electrical drive is for pumping service, and the small, compact, and rigid construction which is possible. A set of this description is very easily converted into a horizontal stationary outfit. Another form of sinking or portable pump, also by Messrs. Frank Pearn & Co., Ltd., is shown in Fig. 3. This is a self-contained closely-built set, taking up very little room.

Fig. 5 shows a standard type "Uskside" pump, specially suited for heavy pressures. As is customary, double-reduction spur gearing is used, although where space will permit a first reduction, arranged with ropes or belt, affords a quieter drive. The pump illustrated has some distinctive features. The valves are of special design, with hard fibre seats and small lift in order to reduce the slip. They open automatically and are spring-closed with carefully arranged and adjustable springs. The waterways are mathematically designed to give a steady and correct flow, thereby reducing friction to a minimum. For high lifts machine-cut steel gearing is used.

The efficiency of a pump of this description reaches as high as 90 per cent., which is some 12 to 15 per cent. higher than can be obtained with centrifugal or turbine pumps, although in the case of the latter the balance is practically restored owing to the greater mechanical efficiency of a direct drive.

At the Duffryn Colliery, near Port Talbot, an "Uskside" pump has recently been installed having 10in. rams by 18in. stroke; the duty is 450 gallons per minute against a head of 600ft. vertical; it is driven by a "Crompton" continuous-current motor operating at 500r.p.m., and of a normal rating of 110h.p. At Messrs. Nixon's Navigation Colliery, Mountain Ash, two 250h.p. pumps of similar make have been installed: each of these is capable of dealing with 450 gallons per minute against a vertical head of 1400ft. The motors in this case are of the three-phase, alternate-current type, operating on a 500-volts, 25-period circuit, and running at 460r.p.m. Two reductions of steel gearing reduce this speed to 29 revolutions at the pump.

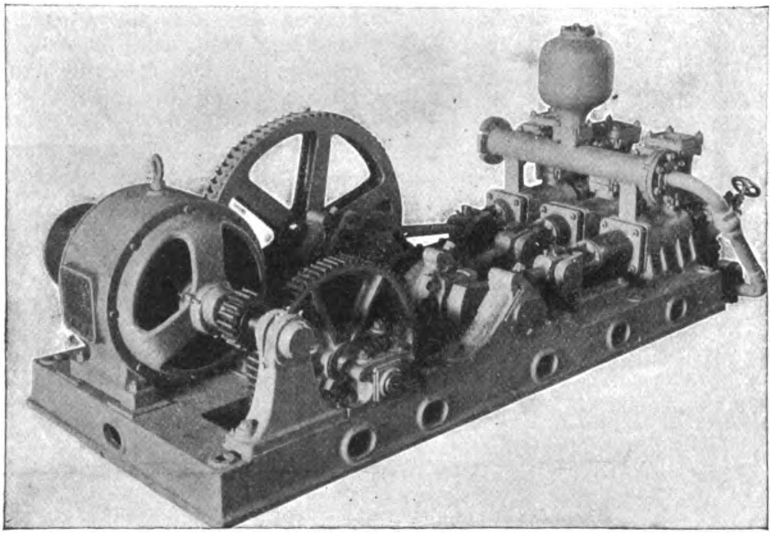

Fig. 5. Uskside Horizontal Three-throw Electric Pump.

These are said to be the largest reciprocating pumps installed in this country, with direct-geared electric motor drive. In connection with the large electrification scheme at Messrs. D. Davies & Sons' Ferndale Collieries, a number of high-lift "Uskside" three-throw pumps have been installed. The two largest have rams 6½in. diameter by 10in. stroke running at 30r.p.m. against a head of 1500ft. Each pump is driven by a three-phase motor of 80h.p. running at 650r.p.m., the reduction being effected, as usual, with a double-reduction machine-cut steel gearing.

The electric pump shown in Fig. 6 is worthy of particular note as being one of the recently introduced high-speed reciprocating types. The development of the high-speed ram pump is entirely a question of valves: many efforts have been made to introduce mechanically-operated valves, but with few exceptions these have not met with any practical success. In this "Excelsior" pump the valves are automatic and certainly very ingenious; the illustrations, Figs. 7, 8, and 9, show their construction and operation very clearly. Each valve consists of a strip of phosphor-bronze sheet coiled upon a spindle to form a spiral, leaving a thicker part of the sheet uncoiled and flat to form the valve flap. The spiral exerts sufficient spring power to gently close the flap immediately the current of the water ceases. The prominent feature of the valve is its extreme lightness; those used in a three-throw pump, running at 350r.p.m. and delivering 700 gallons per hour against a head of 300ft. and 25ft. suction, weigh less than 4oz. each, and of this only the flap, weighing less than 1oz., is put into motion. These flaps easily withstand a pressure of 150lb. per square inch, and it is claimed may be

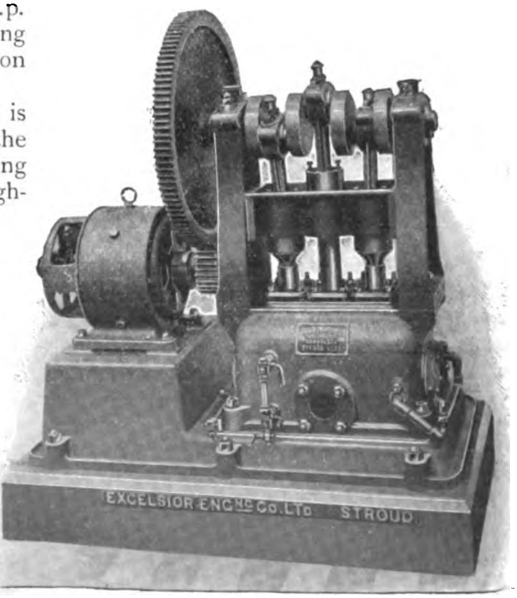

Fig. 6. Excelsior High-speed Electric Pump.

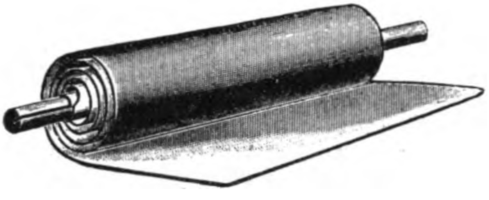

Fig. 7.

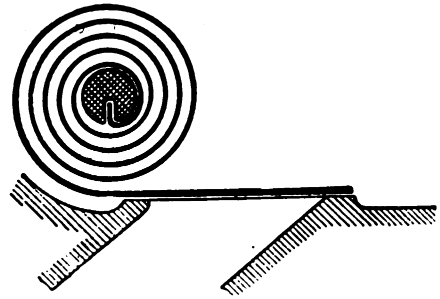

Fig. 8.

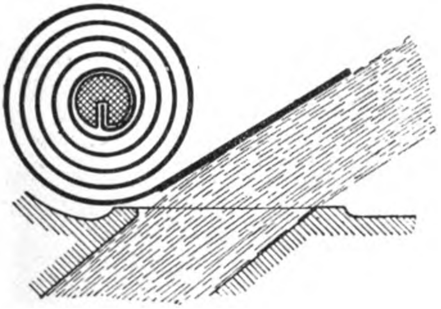

Fig. 9.

modified for use at any pressure up to 3000lb. per square inch. The valves are said to be so sensitive and quick in action that there is practically no limit to the speed at which they can be worked; the limit of pump speed resting in the other moving parts of the pump and its gearing. Figs. 10 and 11 indicate the method of mounting the set of valves for a three-throw pump. They are all assembled in one easily-detachable tapered cylinder or cage. It will be noticed as good features that the valve seats do not enter the direct track of the water, and that the valve opening is of the full waterway area: these not only make for high efficiency but the wear and tear should be very low.

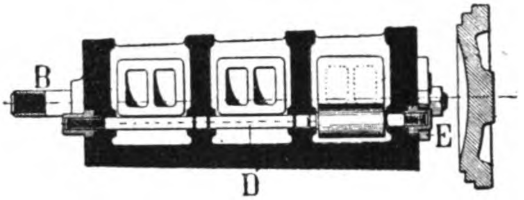

Fig. 10.

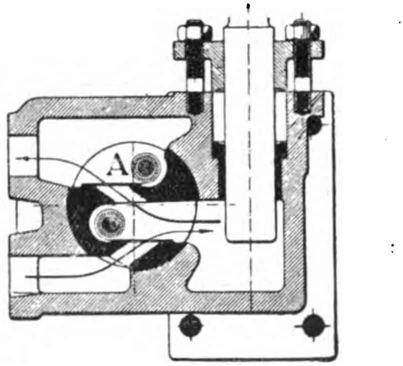

Fig. 11.

A three-throw pump equipped with a belt-drive as first reduction, thus making a less noisy arrangement than double-gear, and at the same time still maintaining a compact form, is shown in Fig. 12. This pump was manufactured by the well-known firm of colliery engineers, Messrs. Andrew Barclay, Sons & Co., Ltd., who also make a speciality of high-speed mining pumps of the ram type. The special feature of these pumps is that they have a mechanically controlled suction valve. The "Oddie-Barclay" system further introduces the differential principle, by which, having two pump chambers in tandem per rod, delivering water at each direction of

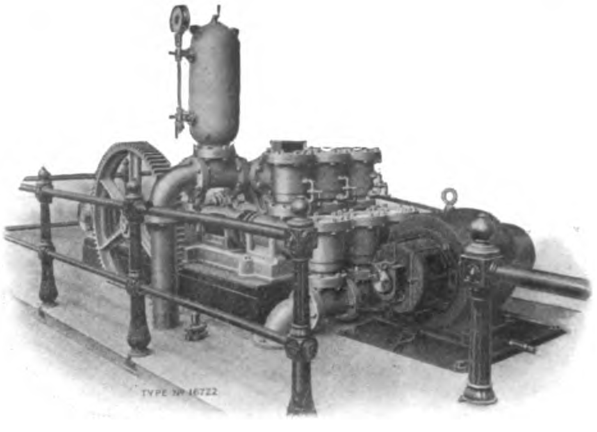

Fig. 12. Three-throw Electric Pump. First Reduction by Belt Drive. Andrew Barclay, Sons, & Co., Ltd

stroke, a steady flow and uniform call for power is maintained. Some particulars of a typical "Oddie-Barclay" equipment are given in the article describing the Tarbrax Oil Company's installation which appears in a later part of this number.

The turbine pumps of to-day are far superior to the centrifugal pumps of a few years ago. Whereas the single chamber centrifugal was only able to deal with heads of about 70ft. as a maximum, and then at a comparatively low efficiency, the turbine pumps are fitted with a number of chambers acting in series whereby any practical lift can be negotiated, and their design has so improved that high efficiency has now become one of their recommendations.

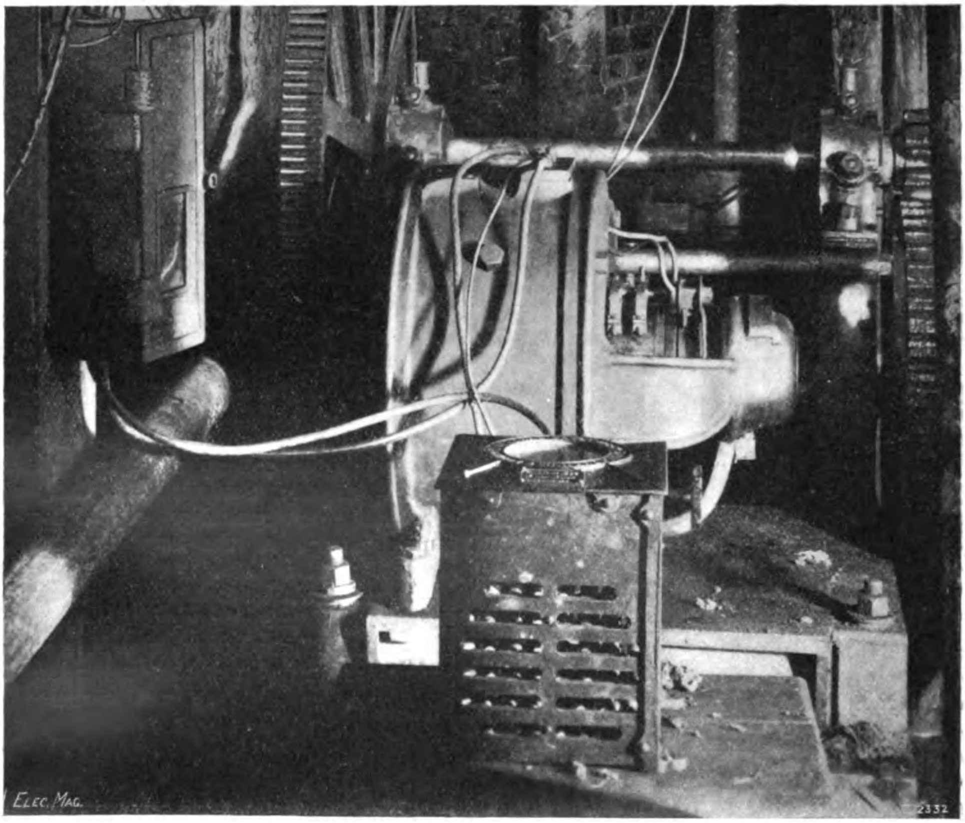

Fig. 13. Small Pumping Set driven by 5h.p. "Witton" Motor, installed Half-way down Pit Shaft. General Electric Company, Ltd.

There are several types of high-class turbine pumps, suitable for mining service, on the market, differing from each other in details and material of construction rather than in principle. Thus the Worthington turbine pump is considerably different from other types at present being put forward, this difference being mainly noticeable in the arrangement of the casing, which in this case is made up in separate sections. The advantage of this method of construction is that it enables the pump to be dismantled in the shortest space of time when necessary, and also enables the pump to be handled in the colliery without any special lifting tackle. In order to obtain the best results the pump shafts are made of high-percentage nickel steel, and the other internal working parts of the pump are of hard phosphor-bronze. Throughout the entire pump the various points at which wear may take place are provided with rings of special metal, which can be renewed at a low cost.

Amongst some of the large Worthington

pumps recently supplied is a five-stage turbine pump installed at the Bridthir Pit of the Powell Duffryn Company, in South Wales. This pump is shown by Fig. 14. The pump delivers 800 gallons per minute against a total head of 712ft., and is driven by a Westinghouse induction motor running at 1450 revolutions.

At the present time the Worthington Company are installing what will be the largest turbine pumping plant in this country for the Powell Duffryn Company's East Elliot pit, each pump being capable of delivering 1350 gallons per minute against a total head of 1645ft., the power for each being supplied by means of a Westinghouse induction motor of 950h.p. In addition to this, there will shortly be in operation two 350h.p. turbine pumps at the Rhymney Iron Company's Pengam Colliery, each of these pumps delivering 600 gallons per minute against a head of 1000ft.

While the Worthington turbine pump is well suited for ordinary mine drainage where the pumps are placed in a fixed position, it is perhaps in regard to sinking work that this type of pump shows itself to best advantage. The advantages are principally due to the economy in space effected, and the ease with which the pump can be manipulated as compared with any arrangement of other steam-driven or electrical reciprocating pump for the same service. When one considers that the cross-sectional space necessary to accommodate a turbine pump dealing with 1500 gallons per minute does not exceed 3ft. 6in., an immense advantage over any other type of pump will at once be admitted.

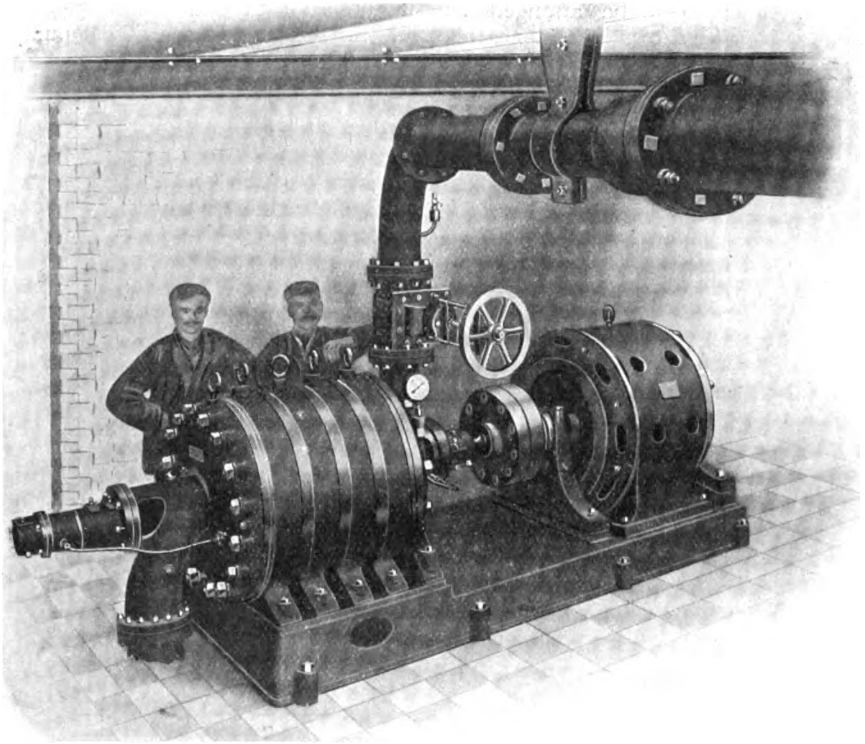

FIG. 14. WORTHINGTON-WESTINGHOUSE TURBINE PUMPING SET.

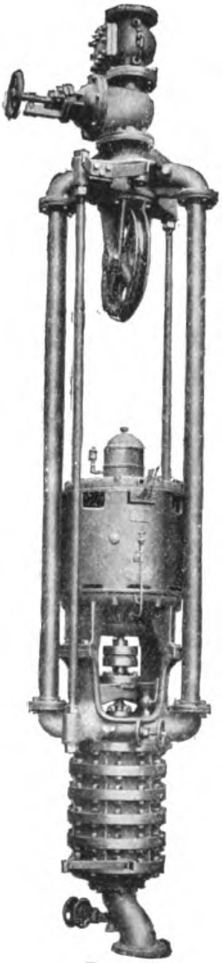

FIG. 15.

The general arrangement of the pump casing is somewhat similar to that of the horizontal type, but the weight of the rotating parts is carried by means of an automatically lubricated thrust-bearing provided with water circulation.

The complete pump can be arranged as shown in Fig. 15, this being more adaptable to the smaller sizes, or as in Fig. 16, which is a photograph of the Tywarnhaile sinking pump taken just before the plant was put into operation some twelve months ago. This particular pump worked for about eight months without ever having been looked at in any way, and in that time satisfactorily unwatered the workings of the mine. It is also interesting to note that it gave satisfactory results under all conditions as regards the height of the suction, which normally reached a maximum of 24ft.

Another type of high-lift turbine pump is made by Messrs. Mather & Platt, Ltd. This firm has supplied a great number of these for colliery service, many of them being of very large outputs. The set illustrated in Fig. 17 has a capacity of 2800 gallons per minute against a vertical head of 265ft.; the motor is of 345b.h.p. The sinking pump shown in Fig. 22 is also by Mather & Platt and is of the vertical-turbine type. This pump is driven by an alternate-current motor and is capable of raising 500 gallons per minute against a total head of 547ft.

A direct-coupled centrifugal pumping set

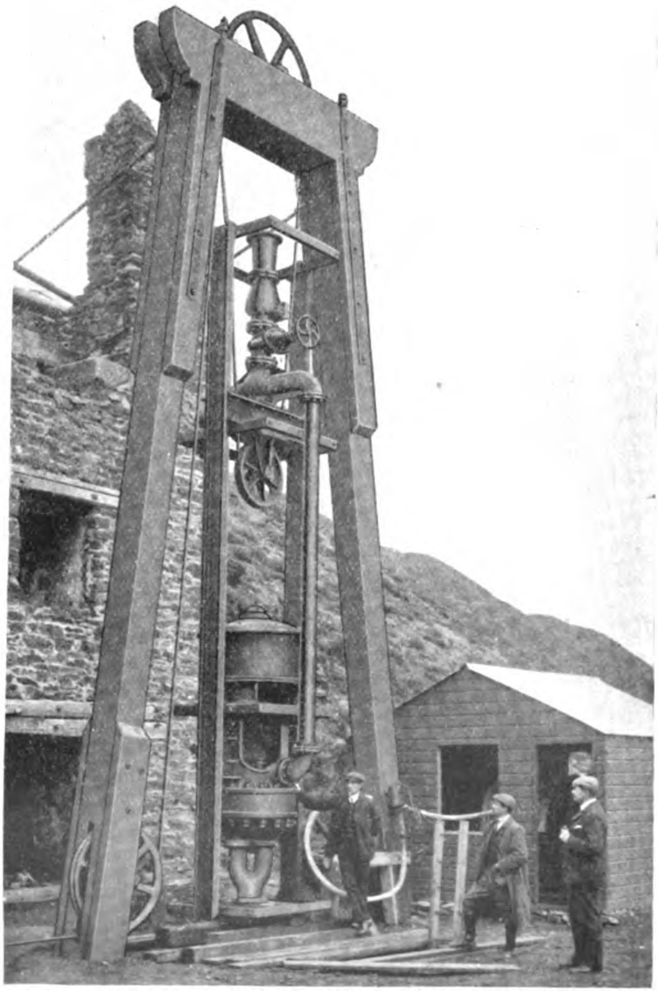

FIG. 16. WORTHINGTON TURBINE TYPE SINKING PUMP.

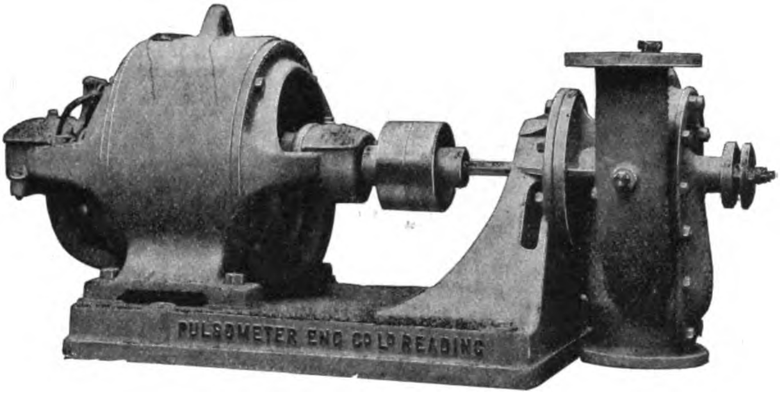
Fig. 18. Centrifugal Pumping Set. The Pulsometer Company.

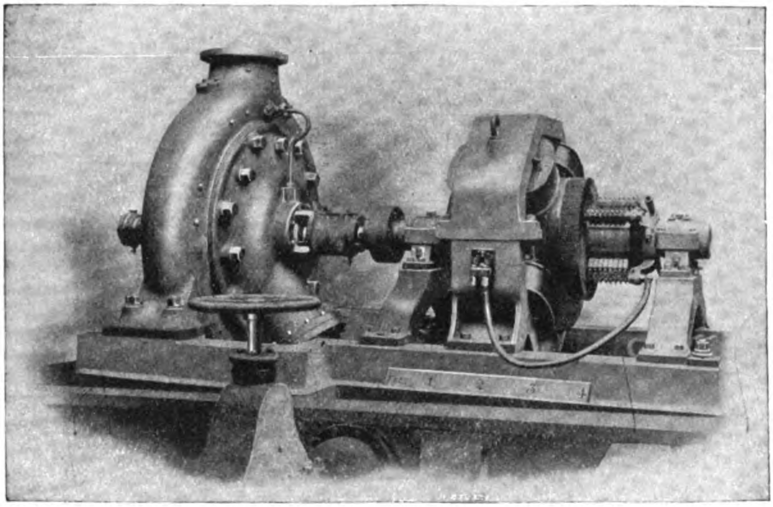
Fig. 17. 345H.P. Turbine Pump. Mather & Platt, Ltd.

by the Pulsometer Company is shown in Fig. 18. Two turbine pumping sets as installed at the Lewis - Merthyr Collieries, Pontypridd, by the Westinghouse Company are illustrated in Fig. 19. In each case the pump is direct-coupled to a three-phase motor of the short-circuited rotor or squirrel-cage type.

Even where the colliery engineer cannot reconcile himself to the use of electricity for all power work in-bye but must still trust to compressed air for such purposes as coal-cutting and drilling, he finds the electric motor invaluable for the driving of compressors. Illustrations Figs. 20 and 21 show typical forms of this plant.

The Brotherhood compressor driven by a Siemens motor, Fig. 20, forms a very compact and handy form of plant for use in colliery workings. The illustration shows clearly the form which this type of compressor takes, the same being totally enclosed and automatically lubricated by splash, a sight feed lubricator being added for cylinder use when required. They are furnished mounted on portable wheel-base when required for moving about collieries and similar places.

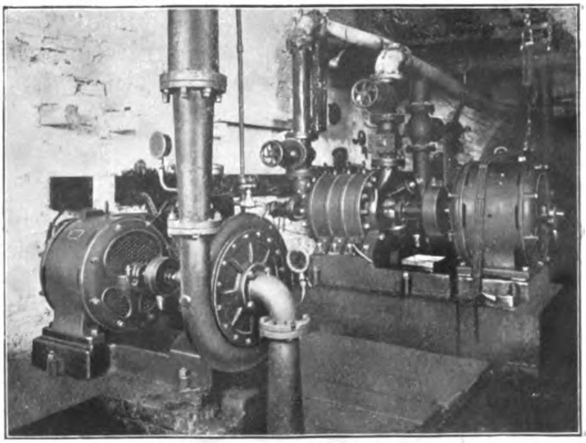
Fig. 19. Turbine Pumps at the Lewis-Merthyr Collieries, Pontypridd.

The Alley and MacLellan compressors have been supplied in large numbers for

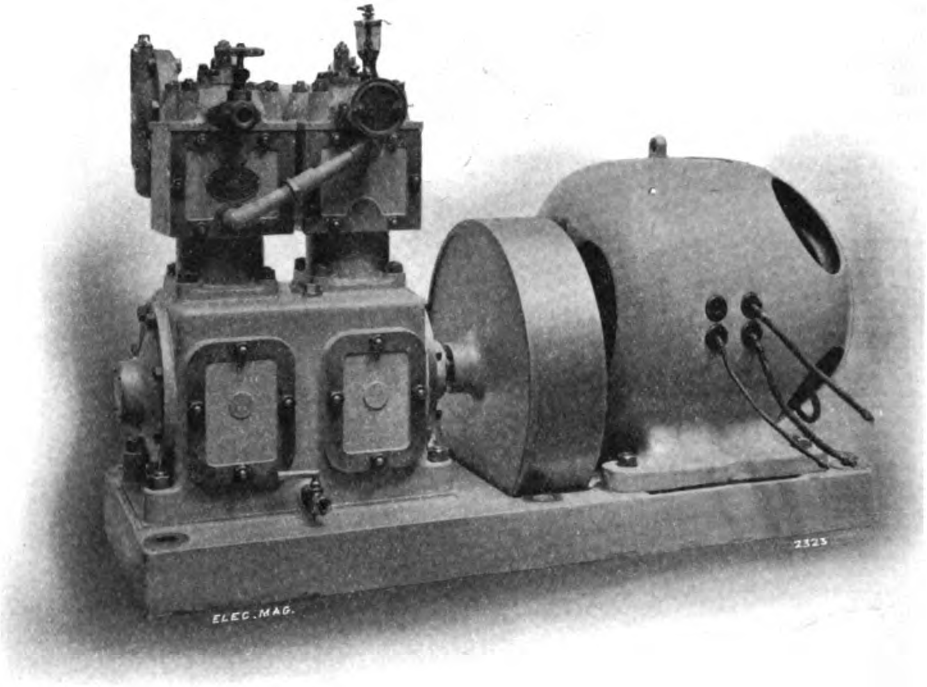

Fig. 20. Brotherhood Compressor, driven by Siemens Motor.

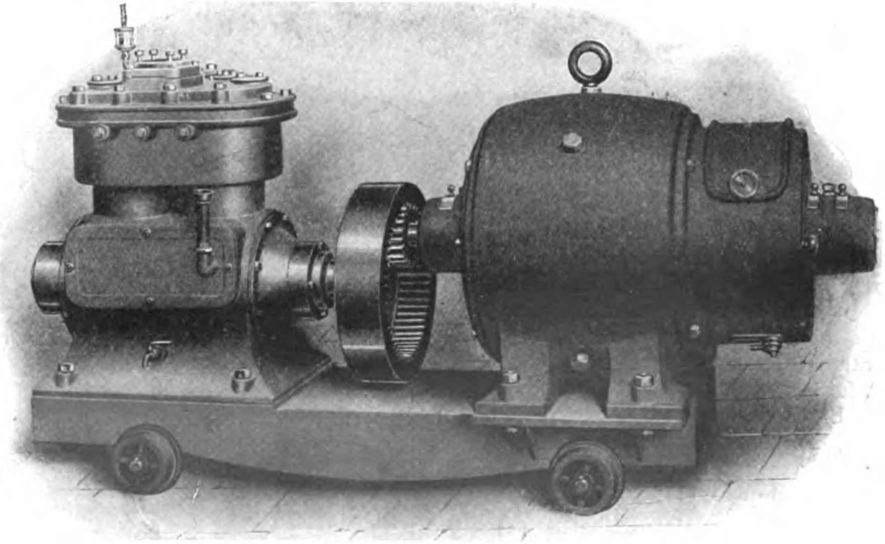

Fig. 21. Portable Electric Compressor Plant. Alley & MacLellan.

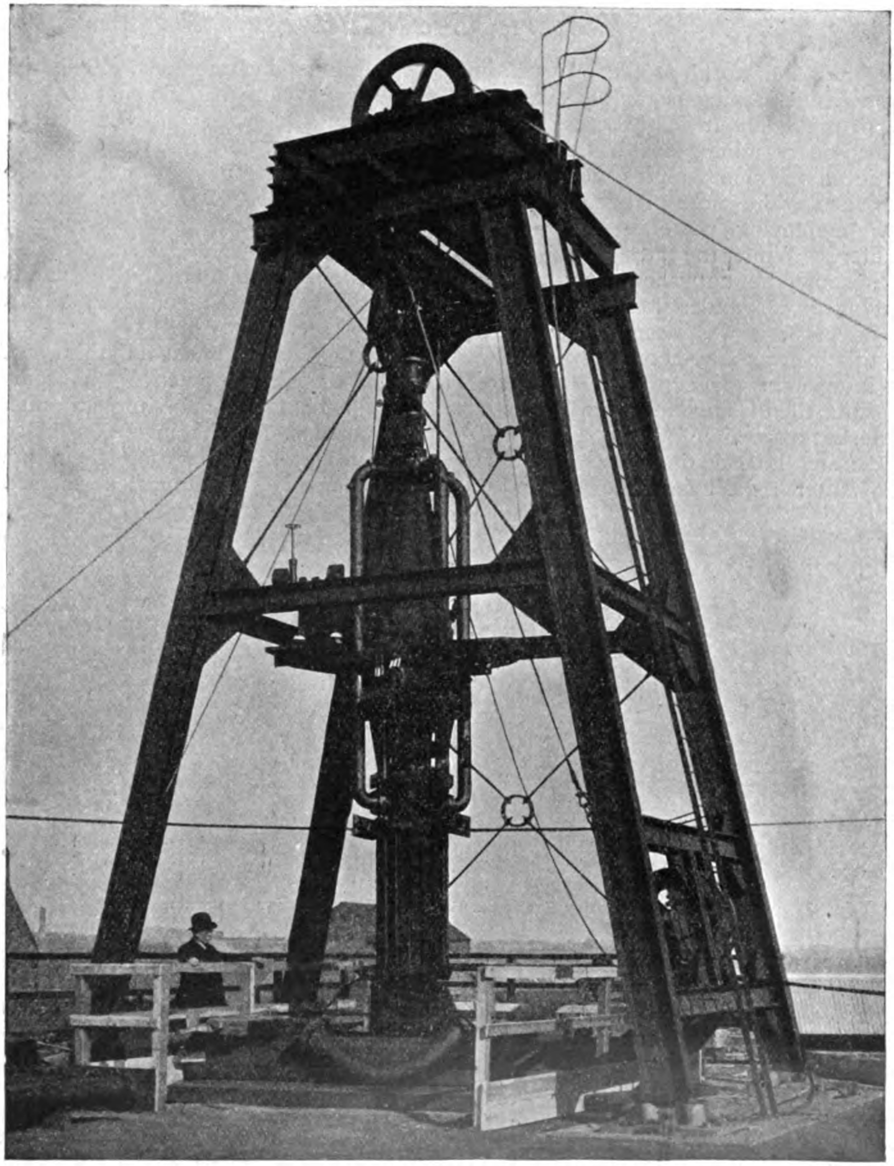

FIG. 22. TURBINE SINKING PUMP. MATHER & PLATT, LTD.

colliery workings. Particular note should be taken of the small portable set (Fig. 21), which is the type generally used close up to the working face of the mine.

The valve gear in this type of compressor is of the entirely automatic style, the valves being arranged in the cylinder cover. Both the cylinders and covers are thoroughly water-jacketed, and the crank case, being entirely enclosed, forms a suitable receiver wherein a sufficient quantity of oil can be stored to enable the machine to run for long periods with little or no attention.

The general type of drive in this class of machine is by gear, as a much lighter motor can then be arranged for. Rawhide pinions are fitted on the motor spindles and the inside racks of compressor wheels. The wheels for the rails are fitted to the combined sole-plate and are of gauges suiting those generally used in mines.

Electric Coal-Cutters.

All over the world at the present time machine mining is rapidly taking the place of hand labour. By successive steps this method of mining coal has grown from mere ideas in men's minds nearly half a century ago to the most practical systems of to-day, employing powerful and effective machinery. While the files of the Patent Offices show the published records of the invention of an undercutting machine as early as 1858, it was nearly twenty years after this before any actual progress was made in machine coal-cutting. The progress made since then is apparent from the details and illustrations which follow.

There are three distinct classes or types of coal-cutters: the chain, the bar, and the disc; the distinction being made according to the form of the cutter arm. All of these are adapted for electric driving, and all are in very extensive use as electric coal-cutters.

The distinctive advantages of machine mining are reduction of labour, increased output, better quality product, and, most important of all, largely increased personal safety for the miner. The advantages of electric power as compared with its only rival, compressed air, for the driving of the machines are: greater economy of operation, superior flexibility of power transmission and machine portability, smaller space occupied, and greater reliability.

Some exception may be taken to this comparison of electricity *versus* compressed air; but it must be remembered that the progress made in electric coal-cutters has been very rapid. Troubles experienced only a few years ago are not to be considered with present-day methods. The time has gone by when experiments by contract between mine-owner and coal-cutter maker were the rule, and when any type of coal-cutter was offered and put down for any class of service. To-day the electric coal-cutter is bought with the same confidence as one would buy an electric motor. The makers have standardised a number of distinct types, each suited to a particular class of service.

In the development of this particular sphere of mining practice this country is again much indebted to foreign enterprise, not, perhaps, for the invention of suitable machines, but rather for their practical development. It cannot be denied that America has been the great trial ground for electric coal-cutters. Yet it will be seen from what follows that the manufacture of electric coal-cutting machinery is firmly established in this country, and that an ever-increasing volume of business is being done in this direction.

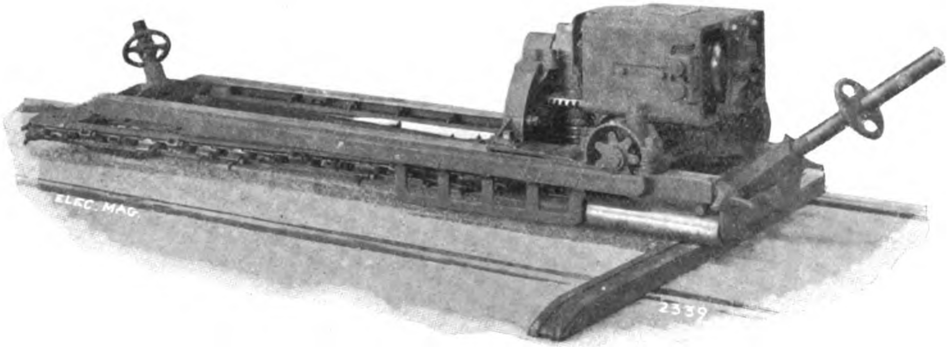

Fig. 1. Goodman Standard Electric Chain Breast Machine.

It is claimed by its makers that the "Goodman" electric coal-cutters enjoy the distinction of having been first in the field. This pioneer machine was of the "pick type," and is now in the Company's possession, it having been returned from the Paris Exposition of 1889, where it took first honours and the gold medal. Prominent coal operators at that time constantly urged the production of a coal-cutter on the mowing-machine principle, one which would itself do the work economically and rapidly, without the continuous strain on a man guiding the direction of the blows. Some

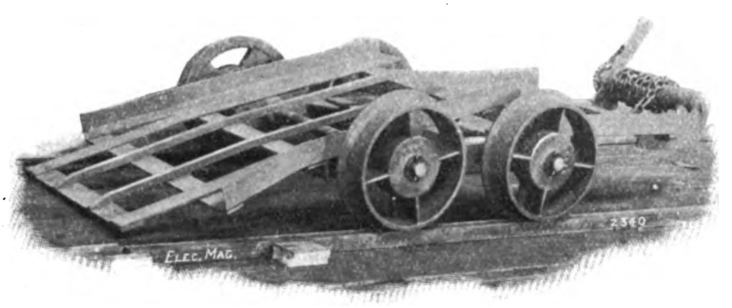

FIG. 2. STANDARD TRUCK FOR GOODMAN CHAIN BREAST MACHINE.

years later the "chain breast machine" was evolved. As said, the great advantages gained by electric machine mining are chiefly shown in the increased output with a given number of men, the better quality of the product, and the reduced cost of mining. The electric machine of to-day, with its powerful motor, rigid frame, and strong cutting instrument, meets and conquers nearly every obstacle met with in undercutting rooms, entries, and pillars, and there is scarcely any mine which could not use some form of mining machine successfully in reducing cost and increasing output.

The general appearance of the Goodman electric chain breast machine is well illustrated in Fig. 1. The principal parts of which the machine consists may be described as follows :—

A stationary frame is held to the floor of the mine by jacks both front and rear, and presents on its upper surface two smooth rails or guides. A motor is mounted on this frame and is capable of sliding along these guides, being driven forward and back by the sprockets at the sides. Attached to the motor is a travelling frame carrying the chain. The chain runs on the outside of this travelling frame and carries cutters, set at different angles, in its links. The angles at which these cutters are set are such that the lowest of them just clears the floor upon which the machine stands, while the highest of them runs about 4in. above this, so as to cut a kerf in the coal of sufficient width for the travelling frame to enter after the cutters. These cutters are held in the chain by set-screws, so that they can be quickly removed and changed when necessary, an operation which is frequent in cutting hard coal containing sulphur.

When brought into operation the machine is unloaded from the truck, shown in Figs. 2 and 3, near the face of the coal, with the forward cutters just clearing the face. The rollers under the rear of the machine are set upon a skid, while the front of the machine stands upon the floor of the mine. The rear jack is set hard against the roof, while the front jack is set upon the coal face. Two men are necessary for the operation of the machine. One of these, the machine runner, stands by the motor, and has charge of the operation of the machine; the other, the helper, places himself near the face of the coal, and shovels away the slack or machine cuttings as fast as the chain delivers them.

From the description of the machine, it will be seen that the train of gears, driven by the motor, performs two operations. It carries the cutter chain with its cutters around the guides or travelling frame, and simultaneously moves the motor and the travelling frame forward upon the stationary frame. The result of this is that the cutters make a kerf about 4in. high and the full width of the cutter head, back under the coal to a depth of five, six, or seven feet, depending upon the length of the machine. As soon as the motor comes to the end of the stationary

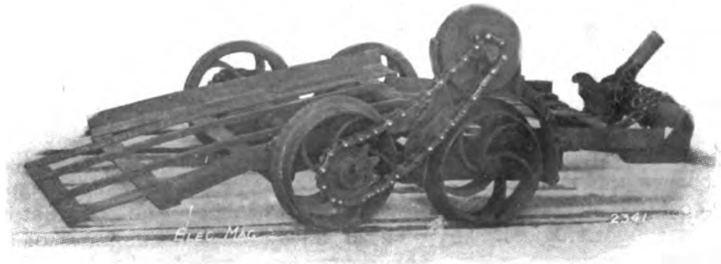

FIG. 3. POWER TRUCK FOR GOODMAN CHAIN BREAST MACHINE.

guides the forward feed is automatically stopped, the operator throws over the reversing lever, and the motor travels backwards, pulling the travelling frame out of the coal. By the time the machine is clear of the coal, the two operators have the jacks loosened, and are ready to move the machine over, re-set the jacks, and make another cut.

The time necessary for these operations is variable, depending upon the character of the coal and the style of feed used upon the machine. It generally takes from three to four minutes to make a forward cut; from thirty to fifty seconds to back out; and, under the best conditions, about forty-five seconds to move over and get ready to start on a new cut. The number of cuts possible in a day will depend not only upon the above conditions, but also upon the width of the rooms and character of the roof and face. From thirty to fifty cuts is an average day's work, while, under very good conditions, as high as seventy-five cuts have been made in one day of ten hours.

The power necessary for operation of the machine is variable. For operating the motor and its train of gears about 10amp. is required at 220 volts. With good, clean coal, sharp cutters and well-lubricated bearings, 25amp. is sufficient when the machine is in full operation cutting coal. If the cutters are not kept in condition, if bearings are not cared for, and especially if there are impurities in the coal, the necessary current may run up to 50amp. or more.

It will be noted from the illustrations that when the machine is drawn back from the coal, the weight of the motor and gearing is supported on rollers. These rollers materially decrease the labour of moving the machine when placing it for a new cut.

The rear jack is arranged so that when it is set against the roof it automatically locks the rollers, rendering the machine as stable when it is at work as if the frame were composed of solid castings. The jacks themselves are of the simplest type. By carrying one or two different lengths of extra pipe they can be adjusted very quickly for different heights of roof. If desirable, the rear jack can be removed entirely from the machine, by simply taking it out of the socket. Unless removed from the socket, it will always remain inclined to the vertical instead of falling to the floor when released from the roof; thus it not only decreases the labour of handling the jack, but it is used by the operator as a lever in moving over the machine. In addition, it lessens the machine runner's liability to injury should the jack slip while the machine is in operation.

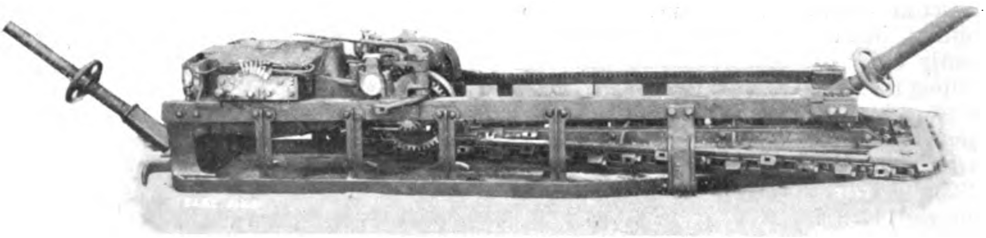

FIG. 4. GOODMAN LOW TYPE BREAST MACHINE.

The travelling frame carrying the cutter chain is supported entirely upon the stationary frame. This gives the machine a marked advantage over types in which the travelling frame is carried between an upper and a lower stationary frame. Every such type of coal-cutting machine makes its cut a certain fixed distance above the floor on which it is standing. In this type the height of the shoe supporting the front of the frame can be adjusted as desired. It can be lowered until the cutters just clear the floor on which the machine stands, so that the machine cuts a perfectly level bottom and thus leaves no coal for the loaders to take up. On the other hand, if the bottom coal is slaty or has other impurities, the front shoe can be adjusted so as to make the cut at any height above the floor that may be desired.

The motor is of ample capacity and well ventilated. Its peculiar advantage is that it is compound-wound, and therefore automatically adjusts its speed to the load imposed. It runs at a moderate speed with light cutting, and slows down with heavy cutting or extremely dull bits. It consequently does hard work with a less expenditure of power than a machine which runs at constant speed. The commutator is readily accessible, and by removing a few bolts the armature can be quickly withdrawn at the rear end of the machine without removing the pole pieces or fields.

The feeding mechanism on this machine is very simple, and, as a consequence, the gears are few in number and ample in size.

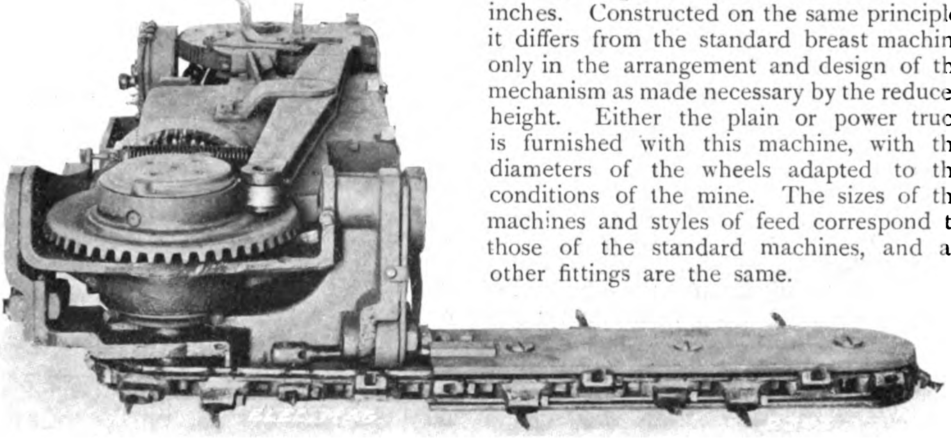

FIG. 5. GOODMAN STANDARD LONGWALL MACHINE.

The frame, being compact, is strong and rigid, with a minimum amount of material. Experience has shown that the strength of this type of frame and gearing enables the Goodman Company to use a heavier chain than is permissible with other types of machines. It is claimed that they are to-day furnishing the heaviest type of chain used on coal-cutting machines.

The motor switch and rheostat are combined, and of compact and durable construction. The switch is arranged with a magnetic blow-out which effectually prevents arcing and consequent burning of contacts.

The truck shown in Fig. 2 is part of the regular equipment, and is furnished with each machine. It is strongly built of steel throughout, with frame specially designed for handling the machine easily and quickly. A suitable drum, with ratchet and chain, at one end of the truck, enables the machine to be speedily loaded or unloaded.

In mines where the machine is to be moved over grades the power truck (Fig. 3) is recommended. It is equipped with suitable gearing of the most simple type, by which the power is transmitted from the machine motor to the truck wheels. So simple, in fact, is the transmission mechanism that the additional time required to load the machine and start the power truck, as compared with the plain truck, is scarcely appreciable.

For mines where the seam of coal is low and worked by room and pillar method, the machine shown in Fig. 4 is suitable. The extreme height of this machine is nineteen inches. Constructed on the same principle, it differs from the standard breast machine only in the arrangement and design of the mechanism as made necessary by the reduced height. Either the plain or power truck is furnished with this machine, with the diameters of the wheels adapted to the conditions of the mine. The sizes of the machines and styles of feed correspond to those of the standard machines, and all other fittings are the same.

REGULAR SIZES OF "GOODMAN" CHAIN BREAST MACHINES

Total Length of Undercut.	Width of Undercut.	Undercut in Inches per Minute.
5 feet	42, 45 or 48 in.	12 to 15
6 ,,	42, 45 or 48 in.	14 to 18
7 ,,	42, 45 or 48 in.	17 to 28

In the longwall method of machine mining the fire-clay underlying the coal is usually cut by the machine. Machines for such mines, as the cutting is quite hard, must be of the strongest and most powerful type.

As illustrated in Fig. 5, the Goodman longwall machine consists of a steel frame about 7ft. in length and 32in. in width, finished smooth on one of the long sides which slides along the face of the coal, and is supported on the bottom on steel shoes. In the middle portion of this

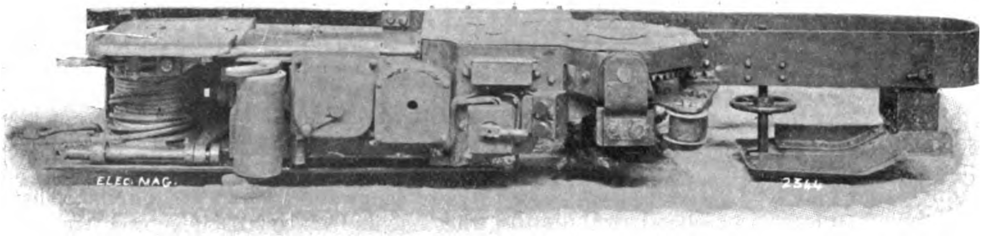

FIG. 6. GOODMAN REVERSIBLE LONGWALL MACHINE (FRONT VIEW).

frame is a powerful electric motor, whose armature shaft, lying lengthwise of the machine, is geared at one end to the sprocket, which in turn drives the cutter chain around a steel cutter arm extending at right angles to the frame. Three lengths of cutter arm are furnished, as desired, to undercut the coal 38in., 44in., or 50in. The narrow cutter arm is carried on a swinging frame, and by means of a lever can be tilted in its width up or down from the horizontal position to enable the chain to cut over or under any especially hard substance.

A cable winding drum at the other end of the machine is operated by the motor by a ratchet lever, with cam attachment to the shaft of the driving sprocket. This drum winds up a wire cable which, attached at one end to the frame, passes around a sheave fastened to a jack say 100ft. ahead, and thus feeds the machine along the face. In starting to undercut, a small jack screw against the side of the machine at the cutter arm end forces the cutter arm with its cutting chain under the coal, where it is retained by the action of the bits upon the clay or coal. No rail or other contrivance is necessary to keep the machine in position, and its narrow width allows of easy handling with props 3ft. from the face.

Strength of frame, protected mechanism, a powerful motor, and durability of cutter arm and chain are the particular guarantees given for this machine. The average work for a machine is 500 lineal feet undercut in one shift, varying with the character of coal and bottom.

In longwall mines, worked by the "block system," where parallel headings give 200ft. to 400ft. of face, the "Goodman" reversible longwall machine is a pronounced success. This machine (Figs. 6 and 7) in its general design is identical with the standard longwall type as just described, but has an extended frame on the cutter arm end. After the face has been undercut and the coal loaded out, as with the standard longwall machine, the jack is set a suitable distance behind the machine and the feeding cable carried back around the machine through the jack sheave and fastened to the end of the extended frame. Rollers at the back of the machine and on the extended frame, as shown in the illustration, protect the cable from wear. Reversing the motor feeds the machine back across the face, making an undercut in the opposite direction, the extended frame serving to hold the machine close to the face. The machine truck is only used when it is necessary to move

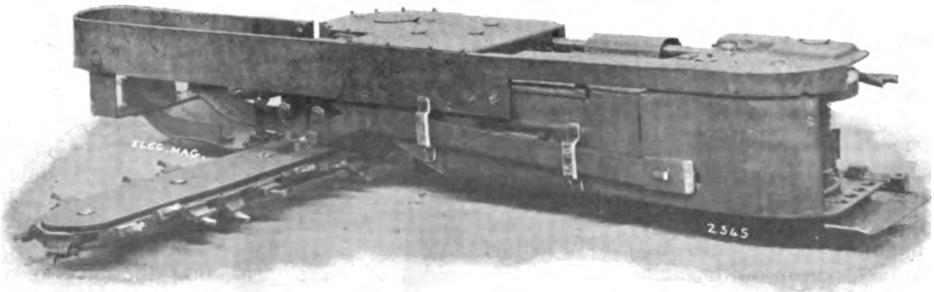

FIG. 7. GOODMAN REVERSIBLE LONGWALL MACHINE (REAR VIEW).

the machine to another section of the mine.

As mining of thin seams by the longwall method is wholly dependent on a uniform and gradual settlement of the room, many mines are opened where the weak character of the roof will not permit the use of this method and a system of room and pillar work must be employed. In such cases the props must be placed close to the face. In many mines of thicker seams, the same condition of weak roof exists, and the impossibility of the use of the breast machine is apparent. For such cases there is the "Goodman" modified longwall machine. This machine is similar to the standard longwall undercutter, but in a condensed form, retaining at the same time all the distinctive features of the standard machine. The three lengths of cutter arms are furnished as desired, for undercutting 38in., 44in., or 50in., but the frame of the machine is shortened to 6ft. length overall, while the width of the machine, exclusive of the cutter arm, does not exceed 48in., these dimensions making it possible to cut across the room face with the props as close as 5ft. The short length of the machine enables the machine runner to cut as close to the rib on one side of the room as on the other, so that the room may be kept the full width.

The Jeffrey electric longwall coal-cutter has been specially designed to suit thin seams, the overall dimensions being: Height from floor level, 19in.; length overall, 8ft. 2in.; width from coal face to trees, 3ft. 8½in.; total weight, 33cwt. The motor is situated in the centre of the machine, and drives through cut-steel gearing enclosed in an oil-tight casing on to the disc pinion shaft. This shaft runs through the long bearing on the movable rocker arm, which is designed to carry the quadrant plate and cutter disc. The rocker arm is moved by the hand-wheel near the starting switch, and by this means the driver can take the disc up into the coal or down into the pavement. Another pair of gear wheels is enclosed in the oil-tight casing, and these drive an eccentric for the ratchet feed gear; the connecting rod from this eccentric works along the "waste" side of the machine to the front, so that the driver has the feed under control, there being a special arrangement whereby he can alter the speed of the feed whilst the machine is in motion; the variation is from 0 to 25in. per minute. The advantage of this is that, the motor being shunt-wound, the feed may be entirely stopped, and the disc be allowed to clear itself, without fear of the motor racing.

The machine is arranged to travel on only two wheels, one at each end, necessitating the use of only one rail. Where two rails are employed, it is seldom that a machine sits fairly on both, and thus it is subject to strain on the wrong parts. With one rail there is less risk of derailment. The laying of the rails is greatly simplified as well, and there is more room for the kervings between the cutter and the rail under the machine.

The position of the driver is at the front end of the machine, where he has the starting switch, the regulator for the feed, and the hand-wheel for moving the disc, all under his control, and, as he can see the work that the machine is coming to, he can regulate the different parts accordingly. The driver does very little more, as the man with him at the front lays the rails. In some seams the driver, when he knows the road, can lay the rails as well, and so dispense with this man, or they may want another man behind the machine to help to set the props. The man behind the machine is the driver's mate, and he clears the kervings from the disc, and he can also hand over the rails and sprag the coal up. The disc runs at a high speed, and clears the holing well, so that there is little cleaning to do after the face is cut.

Discs are made to undercut from 3ft. 6in. to 6ft., those of 4ft. and upwards being split for easy handling below ground. The disc is cast with a grooved rim; tool-holders are fitted into this groove and riveted tight with two ½in. rivets. The tool-holders are constructed to take straight cutters; that is, all cutters are identical, the desired kerf being obtained by fitting in the periphery of the disc a series of holders, some bent upwards, some downwards, and others straight. The tool-holders are made so that they give a minimum surface to bear against the kervings, and should one of them be accidentally broken it can be readily replaced. The form of cutter to be used may be decided upon for any particular seam after a few days' trial; care being taken to ascertain the proper temper for the tools for different holings.

Failures of electrical coal-cutters are often traceable to the starting switch. In the "Jeffrey" machine it is arranged in two boxes, both flame- and water-proof; one

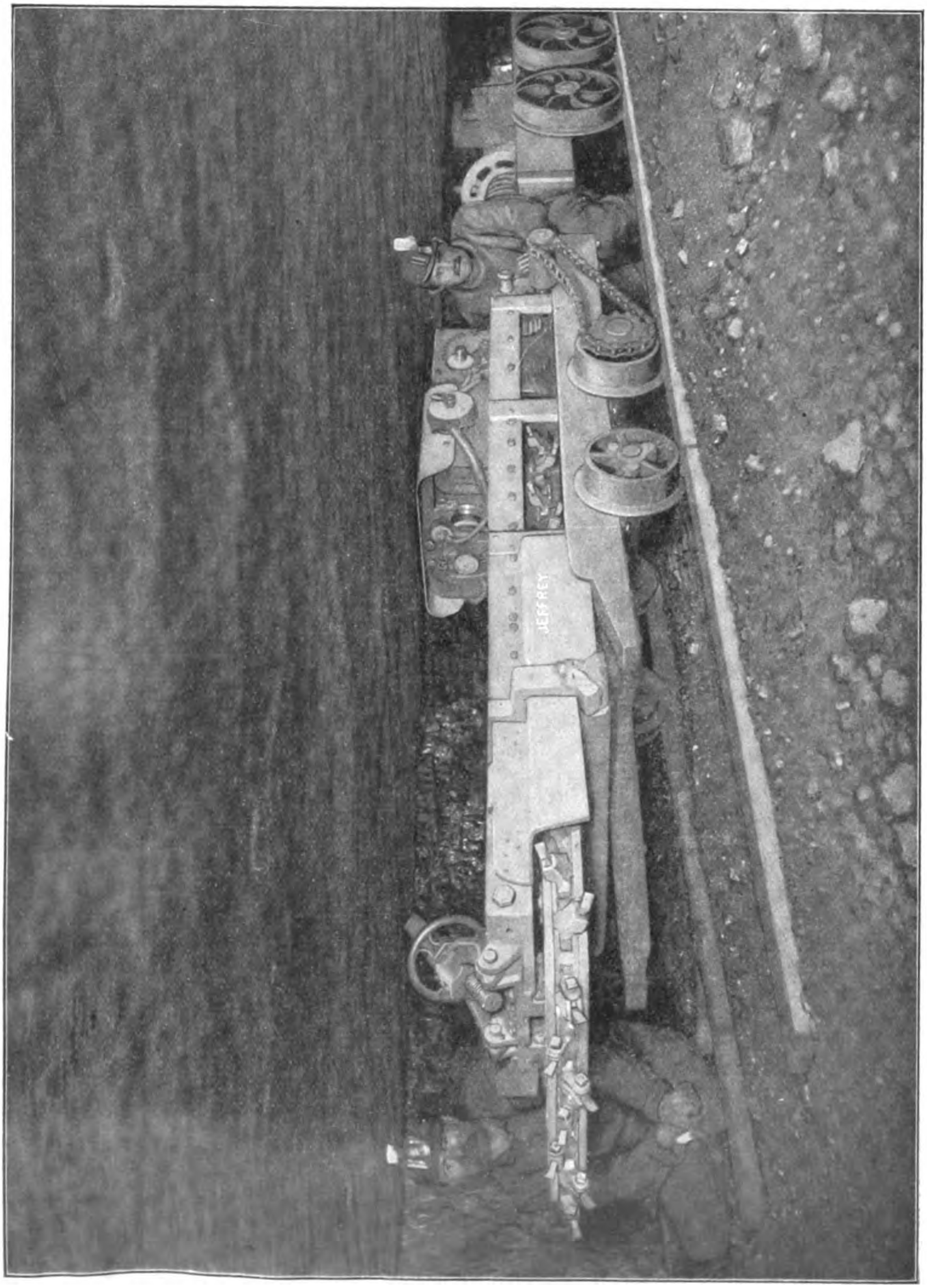

FIG. 8. JEFFREY LOW TYPE ELECTRIC HEADING MACHINE ON SELF-PROPELLING TRUCK.

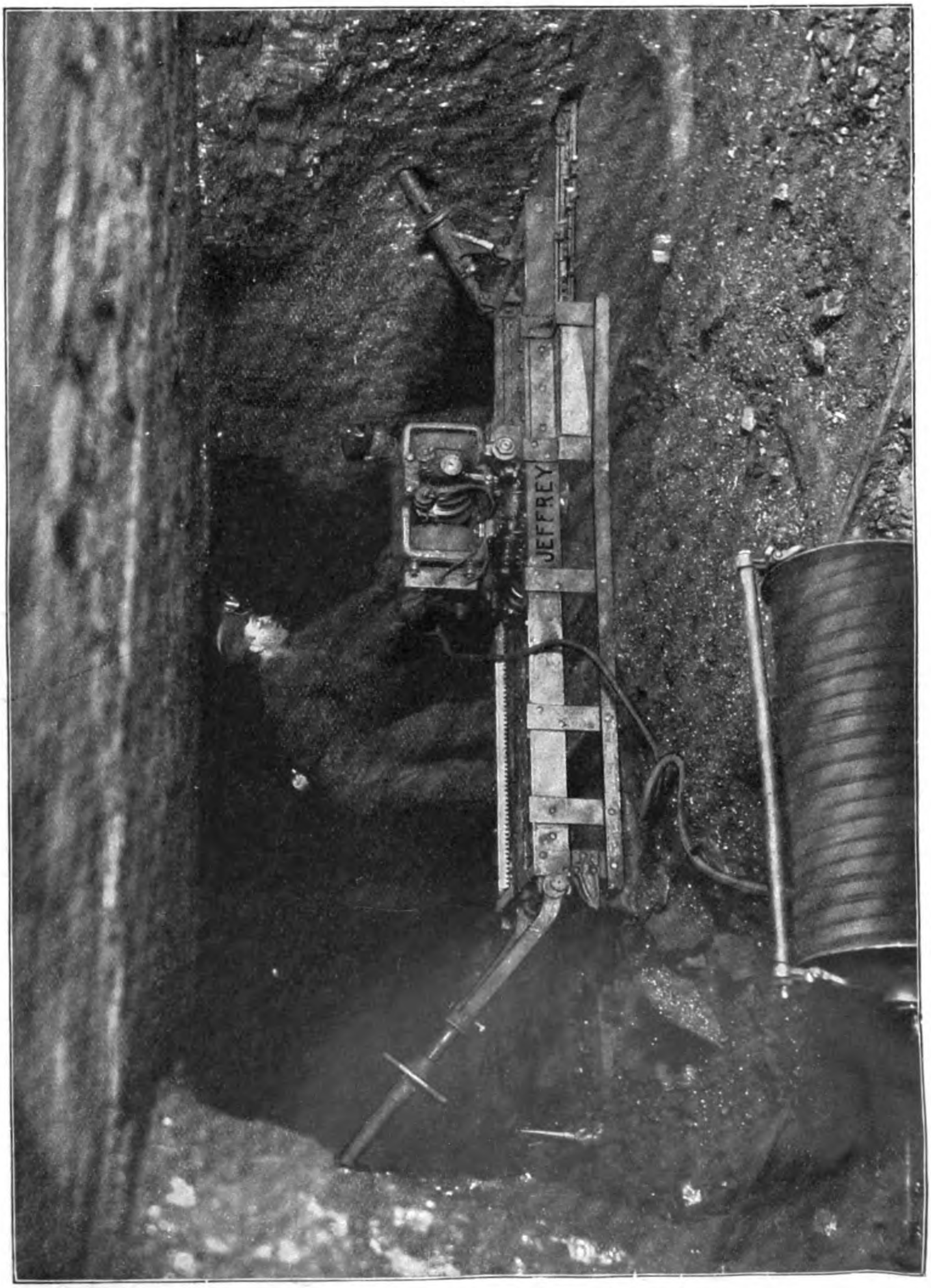

FIG. 9. JEFFREY ELECTRIC HEADING MACHINE IN USE.

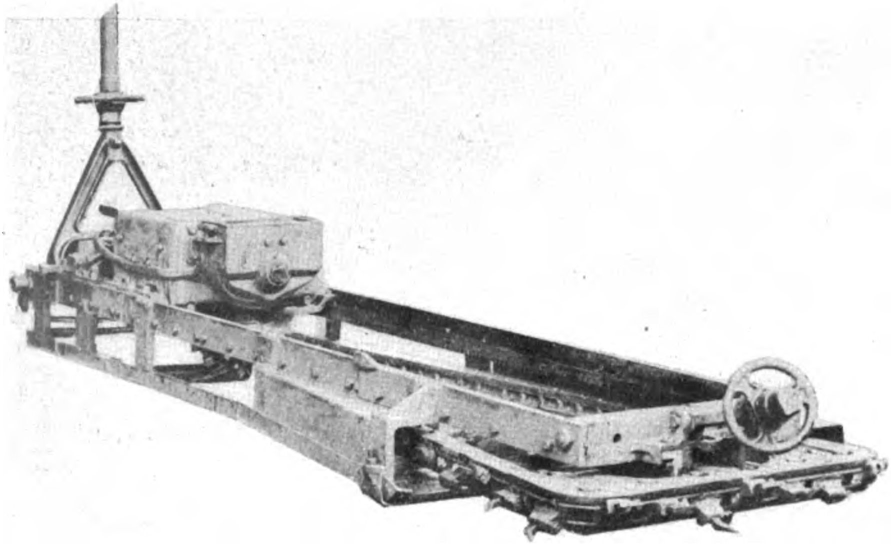

FIG. 10. JEFFREY LOW TYPE HEADING MACHINE (REAR VIEW).

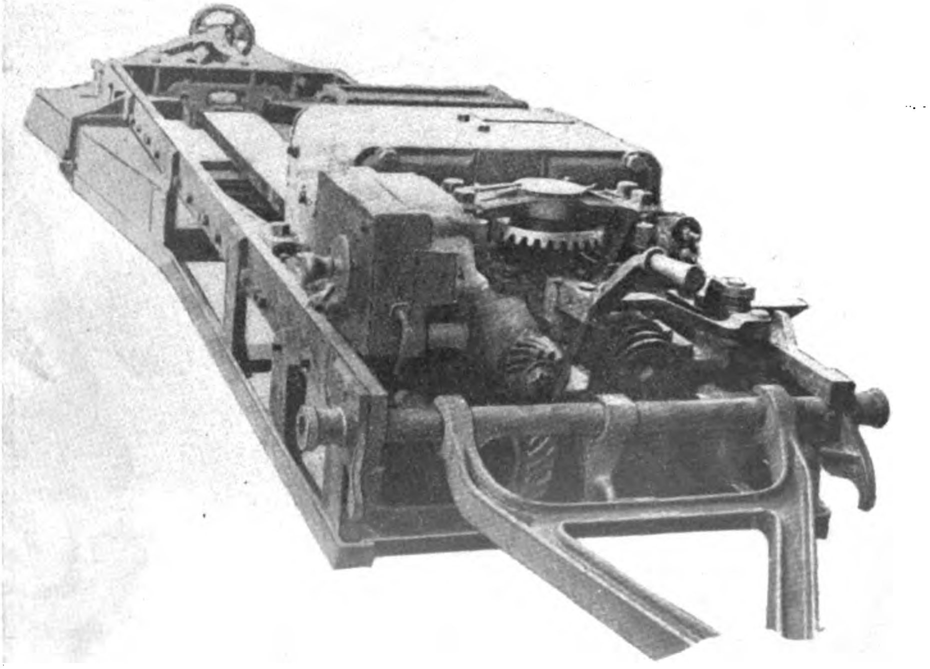

FIG. 11. JEFFREY LOW TYPE HEADING MACHINE (FRONT VIEW).

contains the handle and contacts, and the other the resistances. The resistance box is fixed on to the lid of the gear box at the back of the machine, and the contact box stands vertically at the front of the machine. By pressing a stud on the contact box the circuit is broken quickly. The machine as described may be arranged with sleds instead of wheels, so that rails and sleepers are entirely dispensed with, this depending upon the nature of the pavement.

The "Jeffrey" electrical chain heading machines are made in high and low types, and are used for pillar and stall work, driving narrow places, and where it is necessary to drive straight work quickly. The dimensions of the high type are: Height, 29½in.; length, 10ft. 3in.; width, 3ft. 2in.; weight, 29cwt.

Those of the low type are: Height, 21in.: length and width the same as the high type; weight, 27cwt.

On the high machine the motor is parallel to the coal face, and is geared down through cut straight-toothed wheels to a vertical shaft on which is keyed a sprocket wheel directly below the motor: on this sprocket runs the chain. The difference between this and the low type is that the latter has the motor at right angles to the face and drives through cut bevel wheels on to the vertical shaft, thus allowing the motor to lie further into the frame.

The motor with its gearing is fixed on a movable frame, and is moved forward by two pinions in racks fixed on to the stationary frame. The frame is provided with two jacks fitted with hand-wheels on screws; the one in the front is fixed against the coal, and set at an angle to prevent the tools from running across the coal face and so slewing the machine out of line, the back jack is set against the roof and binds the frame firmly into position to guide the cut. The chain is composed of tool-holders and links passing round the front end of the movable frame on two idler sprockets. The driving sprocket under the motor is the apex of the triangle made by the chain.

On the back shaft are two clutches with a single handle for operating them; one feeds the chain in and the other withdraws it, and the driver can, if necessary, let the chain run idle at any point of the cut. The feed is at the rate of about 6ft. in 3½ minutes, and the return is done in half a minute, but the feed speed depends upon the material being cut, and it may be made as slow as 6ft. in 7 minutes if necessary. There are knock-off brackets attached to the stationary frame preventing the machine from overrunning.

In starting a cut it is usual to work on the left-hand side looking in the direction of driving the place, and then each subsequent cut is made with an open side, but it can be worked from right to left if so desired. The stationary frame is placed on a skid board at the rear end, so that the machine cuts at a slight angle as it starts its cut, about 1½in. above the pavement. This skid-board facilitates the moving over of the machine for the next cut.

These machines are built for undercutting to a depth of 5ft., 6ft., or 7ft., with a width of 44in. and a thickness of kerf of about 4¼in. The usual time occupied to undercut a place 11ft. wide, counting the moving into position and moving out again for firing shots, is about 45 minutes, and simultaneously two shot holes can be drilled, as the men have time to do these whilst the machine is undercutting.

The Jeffrey electrical shearing machine is similar to the header, but the chain works vertically, and it is used for nicking the side of a place. It cuts to a depth of 5ft., 6ft., or 7ft., with a height of 36in. and a width of kerf of about 4in. It is a useful machine for places where the coal will not part from the roof after being undercut, and where shots are inadvisable. In this machine the stationary frame is supported on four iron columns jacked between the floor and the roof, and after each cut it is raised or lowered on these columns to make the next cut.

The electrically driven coal-cutting machine shown in Fig. 12, known as the "Crescent," is made by Messrs. A. Hirst and Son, Ltd., of Dewsbury. It is of special design and construction, being made in three parts, each complete in itself. The first part carries the motor, the middle part carries all the gearing, and the third part carries the haulage gear and starting switch. The motor is of 25h.p., totally enclosed, and fitted with large doors for ready inspection of the interior parts. The armature is of the slotted drum type, former wound, and insulated entirely with mica. The commutator is of large size, made of hard-drawn copper segments, and insulated entirely with solid mica. The commutator end of the armature shaft runs in a bearing fitted to the inside of the box and independent of the end-cover, thus enabling the brushes to be adjusted before the covers are put in place. The field magnets are series-wound, the coils being machine-wound on formers. The gearing is machine-cut throughout, and is enclosed in an oil-bath: the first motion from the armature is by straight wheels, consequently there is no end-thrust on the armature shaft; the bevel wheels are on the second motion and the shafts are fitted with ball thrust bearings. Provision is made for withdrawing all shafts and wheels easily and without trouble. The wheel bracket is bolted on to planed facings on the side of the gear-box.

The front end of the machine is formed with two side-frames bolted together, and carries the hauling gear, which is of the type usually employed in this class of machinery. A special feature, however, is the feeding arrangement, which can be regulated from either end of the machine; one turn of a small handle altering the feed one cog more or less, as may be required. The feed-motion is worked from a small adjustable crank on the end of the bottom shaft in the gear-box.

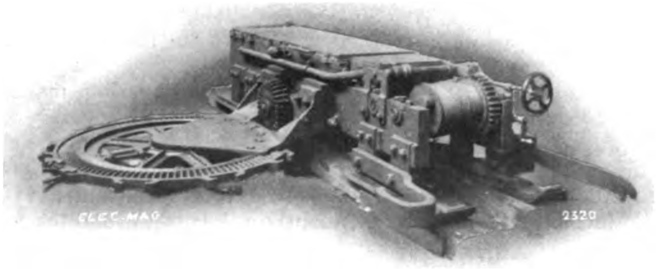

Fig. 12. The "Crescent" Electric Coal-cutter.

The starting switch is of strong construction, fitted with a heavy barrel switch having special magnetic blow-outs to each contact. It is double-pole, and worked by means of a hand-wheel at each end of the machine. The resistance is of large size, enabling the machine to run on this for several minutes when starting out of the stable. The switch is capable of being switched on and off to move the cutter-wheel round from box to box when changing the cutters without any destructive sparking, and without any damage whatever to the switch contacts. The switch barrel and contacts can be removed from the box without disturbing any of the connections or the outside switch shaft.

The cutter-wheel is made in two sizes, 4ft. 6in. or 5ft. 6in., and is fitted with a patented cutter-box, which enables the cutters to be fixed or changed with the greatest ease. The wheel centre is fitted with a special method of lubrication which is continuous and under the control of the attendant.

The coal-cutter is made in two sizes, a high machine and a low one. The former, fitted with skids, gives a height of 23in. when cutting its own floor: the latter has no skids, sliding direct on the floor on planed facings, and this stands 16½in. high. The total length of the machine is 8ft. 6in., and the extreme width is 3ft. 9in. The weight of the high machine is 44cwt., and the low machine weighs 38cwt.

The "Crescent" coal-cutter is made of steel throughout: all the bearings are of hard phosphor-bronze: and the shafts are of a high-grade mild steel and of specially large diameters.

Several machines of this type supplied by Messrs. Hirst are at work in a Yorkshire colliery and are cutting across an 80yd. face in five hours, and have done this for six months without any appreciable wear of the gear wheels.

The conditions in America are no doubt more favourable to the use of coal-cutters than here, but this is hardly a sufficient reason for the greater proportion of machines used in America than in Great Britain, the actual ratio being about ten to one. We may take it from our knowledge of American methods that if the use of machinery in this connection did not pay its use would not be continued and each year show a large increase in the quantity of coal cut by machinery. Tried and proved machines for holing in coal or the strata which under- or over-lies it are now in the English market and are giving more than satisfaction; they are making dividends go up. One of the most popular machines in this country is the Pick-Quick bar type coal-cutter, for longwall working, as made by Messrs. Mavor & Coulson, Ltd., Glasgow. No machine is suitable for every condition, but it is claimed that this machine is the most flexible in its range of application and that it is the one most adaptable to the greatest variety of conditions.

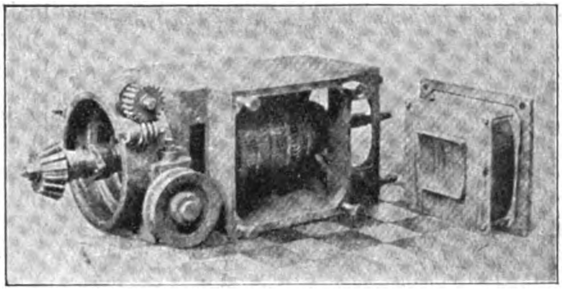
Fig. 15.

The Pick-Quick electrical coal-cutting machine is made in three sizes to undercut respectively to 3ft. 6in., 4ft. 6in., and 6ft. deep. Owing to the small diameter of the bar and the high speed at which it therefore can be rotated, the reduction in gearing is only 2 to 1, an important point when we consider that in the case of the slow running disc types, for instance, this reduction is as high as 60 to 1. A special feature of this machine is that the working parts are totally enclosed. The main gearing (see illustration, Fig. 14) is of mild steel, with machine-cut and case-hardened teeth, and runs in an oil bath; the wear and tear are, therefore, reduced to a minimum. In the direct-current machines the motor is of the four-pole type, having two compound-wound magnet coils mounted on easily removable pole pieces, Fig. 15. The motor is completely enclosed in a shell of highly permeable cast steel. The armature is of the slotted drum type. The core is built upon a cast-iron hub, fitted with cylindrical ends to support the end windings, and provided with an extension to carry the commutator independently of the shaft.

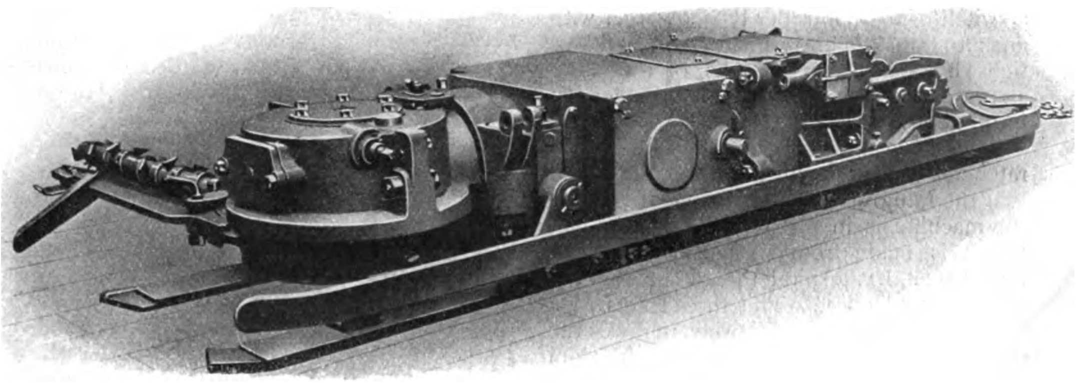
Fig. 13. The Pick-Quick Direct-current Coal-cutter on Skids.

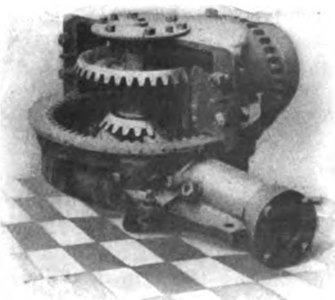
Fig. 14.

In the case of the alternating-current type, the small starting torque required for the cutterbar permits of the use of the simple squirrel-cage rotor without moving contacts; a class of motor aptly described as being as simple as a grindstone. The stator windings are enclosed in a cast-steel shell, Fig. 16, thus preventing any chance of collapse through the falling in of the roof.

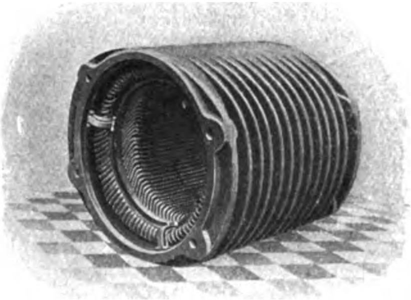

FIG. 16.

In the direct-current type, a double-pole starting switch, to which is attached a patented form of internally-wound resistance tubes, is enclosed in a flame-tight cast-iron box. For the alternating-current machine, a switch of the controller type, together with an auto-transformer, is enclosed in a flame-tight box. The dimensions of the auto-starter and switch are such that immersion in oil is not necessary.

The haulage gear, driven by the usual ratchet wheel arrangement, is so constructed that the rate of feed can be regulated while the machine is in motion. The cutter bar, which is made from a special quality of nickel steel, has a spiral thread cut from the solid, formed on it. This thread acts as a worm conveyor, and effectively removes the cuttings from the holings, giving freedom for the coal to drop. The cutters can be arranged mounted either between or on the top of the thread, and are readily removable. By means of a renewable thrust collar, Fig. 17, on the end of the bar a reciprocating action is imparted to it; this gives a chipping as well as a shearing action to the cutters. The cutter bar can be readily inserted or removed from the case which contains the main gearing without disturbing the latter. An important point in the construction of this machine is that the cutter bar can be swung through an angle of 180deg. in the horizontal. This allows the bar to be used at either side of the machine, and with suitable lubricating arrangements an undercutting machine can be readily adapted for overcutting.

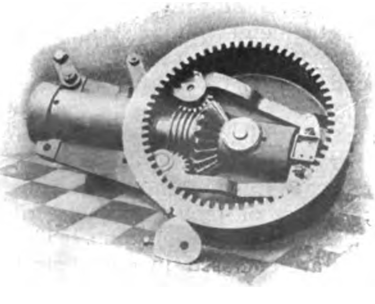

FIG. 17.

Besides machines of the electrical type Messrs. Mavor & Coulson, Ltd., also manufacture the compressed-air type, and in all cases the parts of machines, of corresponding size, whether direct-current or three-phase electric or compressed-air, are interchangeable, excepting of course those parts peculiar to the driving motors.

The practice at present in vogue is to mount the machine on skids, thus saving the use of a man and doing away with the necessity of handling rails. It is found from experience that machines mounted on skids sit down better to their work than those mounted on rails. While on this point reference may be made to the amount of power required to drag a machine on skids along the pavement as compared with one mounted on rails. It must be remembered that relatively speaking the lineal advance is slow. If the weight of the machine is 2 tons, to lift it bodily at 2ft. per minute would only require the expenditure of about ¼h.p., and it is obvious that less power will be wanted to drag it along the floor. The friction due to side pressure on the props which guide the machine must be allowed for, but this is counterbalanced to some extent in the case of the machine on rails by side pressure of the wheels upon the rails.

Durability and long life of the various working parts are claimed as special features of the Pick-Quick machines. In order that no delay may take place in the supply and fitting of renewals, the parts are numbered and made to standard jigs and gauges, being interchangeable between machines of the same size. As evidence of the reliability of this machine, cases have been authenticated where the total cost for repairs and renewals only amounted to 6d. per 100 tons produced, and 5s. per 1000 tons is not uncommon. In one particular instance a machine of the medium-size direct-current type in a year's working produced 27,000 tons of coal with no cost for repairs, and at the end of that period it was only found necessary to make a trifling renewal costing 8s.—surely a record. Another view can however be taken of this question of repairs, if we consider the matter in this light. The cost of a repair or renewal may in itself be a matter of small moment, yet if the machine be thereby thrown idle for any considerable period causing the loss of a shift, the coal-master has to face decreased output with consequent pecuniary loss, and the miner may be poorer by a day's wage. The coal-cutting machine which costs least on the scores of overhaul and renewal of parts is bound in the long run to be the one most eagerly sought after.

The energy used is of no little importance to the colliery manager, and is best stated in electrical units per square yard undercut. To give figures per ton produced is misleading, the tonnage depending on the thickness of the seam. For holing in medium coal, the energy expended is on an average about one-third of a unit, hard fire-clay about .7b.t.u. The limiting factor in respect of the hardest material which can be profitably holed is the cutters. If the strata in which it is intended to cut is free from grit or sandstone, the cutters will stand well; if ironstone nodules and grit are present in large quantities, it is better to cut in the coal than face the excessive renewal of cutters and the increased wear-and-tear

Particulars of Seam ..	Thickness of Coal	Thickness of Dirt	Inclination of Face	Position of Holing	Nature of Holing	Character of Roof
	1ft. 4in.	2in.	1 in 15	Bottom	Coal & Fire-clay	Moderate
Particulars of Face ..	Length	Distance between Gateways	Distance from Face to Pack	Height at Face	Number of Men per Place	Time required to Clear the Face
	142yd.	15yd.	5ft.	1ft. 6in.	2	8 hours
Particulars of Machine	Number	Type	Size	Rails or Skids	Style of Bar	Length of Bar
	1/2983	d.c.	small	skids	taper	3ft. 3in.
Consumption of Power (From Switchboard) Loss in Cables 5 per cent.	E.M.F. at Switchboard	Current	Power Delivered to Circuit	Power Expended by Motor	Energy Used per Sq. Yd. Cut	Energy Used per Ton Produced
	480 volts	20amps.	9.6kw.	10.5b.h.p.	.34 Elec. Unit	.80 Elec. Unit
Performance of Machine	Depth of Cut	Average Lineal Cut per Minute	Average Lineal Cut per Shift	Cutting Back & Forward Turning, or Flitting	Average Shift. Bank to Bank	Shifts Worked during Month
	3ft.	13in.	142yd.	back & forward	13 hours	20
Month's Production ..	Average Output per Shift.	Output for the Month	Average Yield per Lineal Yard	Proportion of Small	Lineal Distance Cut per Month	Face Advanced during Month
	51 tons	1080 tons	7.2cwt.	not taken	2840yd.	20yd.

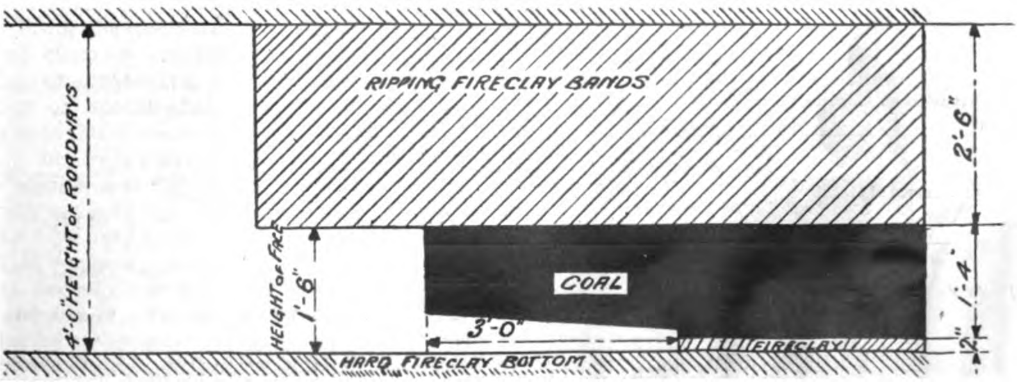

FIG. 18.

of the machine. The particulars on the previous page, and Fig. 18, show the results of a representative month's working in a Lanarkshire colliery with a Pick-Quick machine.

The seam shown is a thin one, but it must be understood that in seams up to 6ft. thick machines of this type are working and giving highly satisfactory results.

The record of a year's working of one of the large size Pick-Quick three-phase machines is shown below. In this case the machine is an overcutting one, and it is interesting to note that the distance cut in a shift is limited by the quantity of coal which can be cleared in time for the machine to make the next night's cut.

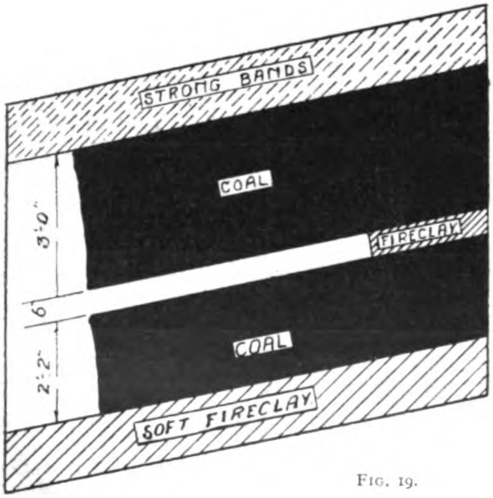

FIG. 19.

At the colliery from which these results were obtained the Pick-Quick machine, fitted with three-phase motor of the squirrel-cage type, was the one selected after prolonged trials with other types of machines, as giving the most satisfactory results. This particular colliery company have now six Pick-Quick three-phase bar coal-cutters at work.

The selection of a suitable driver for a coal-cutter is a matter of no mean importance. He must be a man of a mechanical turn of mind and a miner. On the driver depends the whole output from the face on which his machine is working, and if he is not thoroughly conversant with his tool, a slight hitch in the running of the machine may dislocate the whole working of the face, with consequent decreased output. A coal-cutter when at work is not a quiet machine, and above the sound of its working his trained ear is able to distinguish sounds which tell him of danger, and enables him, if possible, to avoid it. The driver of a coal-cutting machine must sympathize with it; he should not push it beyond its endurance. In soft material the rate of travel will be faster than in hard, and as the section often changes the man who gets most out of his machine is the one who carefully notes these changes and goes faster when in easy holing, but slackens off when the holing gets stiffer. Drivers possessing all the desirable qualifica-

Particulars of Seam ..	Thickness of Coal	Thickness of Dirt	Inclination of Face	Position of Holing	Nature of Holing	Character of Roof
	5ft. 2in.	6in.	1 in 5	26in. above pavement	strong fireclay	bands
Particulars of Face ..	Length	Distance between Gateways	Distance from Face to Pack	Height at Face	Number of Men per place	Time required to strip the Face
	200yd.	one road only	4ft. 6in.	5ft. 8in.	15	6 shifts
Particulars of Machine	Number	Type	Size	Rails or Skids	Style of Bar	Length of Bar
	4	three-phase	large	skids	parallel	6ft.
Performance of Machine	Depth of Cut	Average Lineal Cut per Minute	Average Lineal Cut per Shift	Average Shift Bank to Bank.	Output to Haulage per Man per Shift	Total Costs d/d to Haulage*
	6ft.	18in.	70yd.	8 hours	5 tons 10cwt.	1/5 per ton
Year's Production ..	Average Output per Shift	Output for the Year	Area Undercut	Previous Cost by Hand Holing	Increased Value of Output	Saving by Machine
	168 tons	30,966 tons	28,500 sq yds.	2/6 per ton	4.4d. per ton	1/5.4 per ton

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* Costs d/d to haulage include: Machine labour, getting, filling, tramming, power supply, cutter picks, oil, repairs, and interest and depreciation on coal-cutter and its accessories at 18 per cent. per annum, but Stone Ripping is not included.

tions are difficult to get, and their services at the present time are highly remunerated. Sharp cutters must be insisted on, and spare sets kept by the machine. Working with blunt cutters means the expenditure of unnecessary energy, the machine being thus needlessly strained. Owing to the vibration set up, nuts will work loose, and these require constant attention. The lubrication of the machine must be done carefully, and oil holes thoroughly cleaned when necessary, and that is often, in order that the oil may get to its proper place. These and other details demand constant vigilance, and much worry is avoided and money saved by proper attention to them.

Machine mining has come to stay, and its recent progress has been no doubt in a great measure due to the ease and economy with which electric power can be carried to the working face and future extensions added. For compressed-air coal-cutters a limited field, depending upon the exigencies of the colliery, will still be open, but for flexibility and economy it can be no rival to its younger competitor, electricity. If in this country the general adoption of coal-cutting machines has been delayed, the present need for them is the more acute. The number of machines at work is now rapidly increasing, and their proved success, especially in the thinner seams, leaves no room for doubt that a very important development of machine mining is in progress. The mechanical coal-cutter will bring augmented profits to the coal-master; higher wages, less arduous labour, and greater safety to the miner; and, it may be hoped, cheaper coal to the consumer.

The Development of the Hurd Coal-Cutter.

From the point of view of both mining and electrical engineering the evolution of the bar coal-cutting machine must be a subject of special interest. Long ago the potentialities of a bar fitted with cutters as the instrument for holing coal were observed, and in the early seventies several patents were taken out for this class of machine coal-cutter.

At a special competitive test inaugurated by an agricultural society in the East Lothians in 1874 a number of coal-cutting machines were brought together, and amongst these a bar machine. The bar was rectangular in section and the cutters threaded on from the point, distance pieces being used to keep them at the proper spacing.

Although the gold medal and liberal expenses offered as an inducement to the competitors were eventually won by a disc machine made by Mr. Frederick Hurd, the bar machine greatly impressed the judges with its possibilities.

On the introduction of electricity into mines as a motive power the bar type of coal-cutting machine found more supporters, and Messrs. Goulden, Ravenshaw, and Atkinsons made various types of electrically driven machines.

Messrs. W. T. Goulden & Co. worked these patents, and their last machine, which was designed mainly by Mr. Frederick Hurd, gave good practical results. Many of them were made and set to work in various parts of the country; but the use of electricity was new, the many difficulties of coal cutting by machines were not thoroughly tackled, and consequently the machines fell into disuse.

In 1892 Mr. Frederick Hurd, conjointly with his son, Mr. F. W. Hurd, designed and patented an improved bar machine, but it was not till 1895 that a machine was set to work under a cutting contract at a colliery in Scotland. Mr. F. W. Hurd provided the machine and the labour, the colliery company supplying the power and clearing the coal after the machine had undercut.

The cutter was driven by an 18b.h.p. motor, with cast-iron frames and pole pieces, and malleable iron yokes; it was series-wound and totally enclosed and had an armature of the Gramme ring type. The starting switch was double pole, the resistance being of iron wire wound layer over layer, adjoining wires being spaced by twine and alternate layers with mica. It is interesting to note, as compared with present-day practice, that the switch apart from the resistance contained more separate parts than the whole of the rest of the machine, including the cutters. All the main frame of the machine was of cast iron. The gearing was machine-cut, the driving pinions being of phosphor-bronze and the wheels of mild steel; the gearing was arranged to run in oil.

The working face was on an incline of 1 in 5 and a rack rail haulage gear was used at first, but this was afterwards replaced by the ordinary ratchet wheel and pawl gear and haulage rope taken one bight round a pulley fixed ahead of the machine.

The cutterbar was plain tapered with the cutters arranged spirally. They were double ended, and went through the bar diagonally, so that though the cutter holes were 2in. pitch the cutter points were 1in. pitch ; a split pin through the centre kept them in place.

ELEC. MAG. 2337.

Mr. Frederick Hurd.

The machine was set to work on a 75yd. face, holing 3ft. 6in. deep in a fire-clay in the centre of the seam, and about 20in. up from the pavement. The power required was 50 to 70amp. at 400 volts. It took anything from 10 to 24 hours to cut this face. There were no breakdowns, but the cutting speed was very slow. Headings were cut at each end of the face, and at the start the machine cut the first few feet quickly and very easily; but as the bar cut its way further into the solid, it gradually choked up, until the motor was overloaded to the extent of 50 to 80 per cent. This continued the whole night through, the temperature of the machine, including cutters and cutterbar, gradually rising. It speaks very well indeed for the old Immisch motor that it stood this trial for over six months. So long as the motor would not boil the tea in the men's flasks, conveniently stood upon it, the running was considered fine. Patience was about exhausted all round, men knocked up by long and wearisome shifts, and miners grumbling because they had to hole the coal again after the machine; the contractor lost money, and the entire scheme was financially a failure. But it was of great practical value as experience.

When watching the machine starting so easily out of the headings one night, it occurred to Mr. F. W. Hurd that if the cuttings could be taken away as soon as made, the friction on the bar would be reduced. Several means of doing this were thought out and partly made before the idea of cutting a conveyor thread on the bar itself was evolved. Its simplicity was undoubted, and a bar with a thread $\frac{7}{8}$in. deep, $1\frac{1}{8}$in. broad, and $4\frac{1}{2}$in. pitch, was made under considerable difficulty and fitted to the machine. The transformation was wonderful; the machine literally walked away, cutting at the rate of 4ft. to the minute, and finishing the cut barely warm. The current required was reduced to 15 to 20amp.

From this point the ultimate success of the coal-cutter was assured. The cutting instrument was right, and it only remained to perfect the working parts of the machine and its various adjustments.

Much valuable experience was gained during the period following the addition of the conveyor thread to the bar, and several other novel features in addition to this were introduced into new patents taken out by Mr. F. W. Hurd.

ELEC. MAG. 2336.

Mr. F. W. Hurd.

The bar and its bearings were carried in a separate gear case, arranged so as to swing in and out of the holing, and to cut from either side of the machine.

The gear head was pivoted, so that the

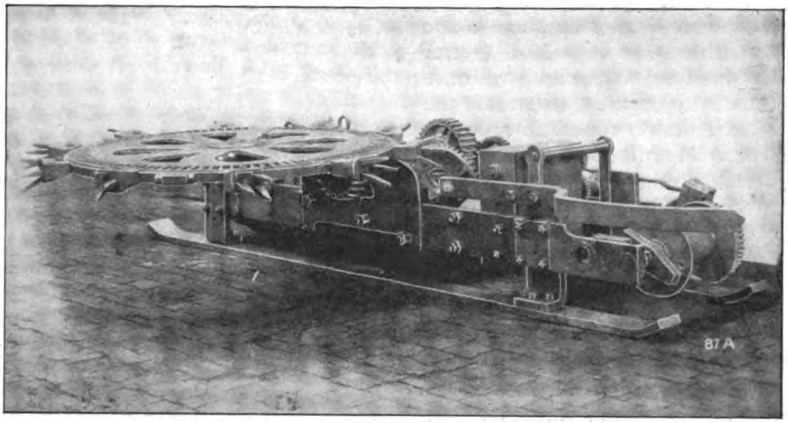


Fig. 20. Diamond Longwall Disc Machine for Three-phase Circuits.

cutting could be done on the floor level or the whole head turned upside down to cut at some distance above the floor level. An extremely simple method of giving the cutterbar its reciprocating motion was devised to make the machine sit solid on its running wheels. The front axle was pivoted on its centre, giving practically a tripod base to the machine. Means were provided for altering the rate of travel without stopping the machine. A cleaner-blade immediately behind the cutterbar was fitted to hold up the cuttings to the conveyor threaded bar, and so bring the bulk of them from below the coal.

The first machines embodying all these improvements were set to work at a colliery in Staffordshire, Mr. F. W. Hurd again supplying the machines and doing the cutting on contract, and while there was considerable trouble during the first few months with various details of the machines, this was entirely overcome, and during the last four months of the contract not a cut was lost, one machine cutting 4913 square yards in 46 shifts, the repairs, except for sharpening cutters, being nil.

The satisfactory working of these machines may be said to have marked the turning point in the rather chequered history of the bar machine. Several other machines were made and set to work with equally satisfactory results, and the "Hurd coal-cutter" became an item of much interest to mining men and gradually established itself as a machine of practical worth.

In 1899 Messrs. Mavor & Coulson, Ltd., of Glasgow, and later on Messrs. Cowlishaw, Walker & Co., Ltd., of Stoke-on-Trent, made arrangements to manufacture the machine under licence from Mr. F. W. Hurd, and there are now over 200 machines at work.

Mr. F. W. Hurd has again taken up the manufacture of his machines, his firm being Messrs. Hurd, McKendrick & Co., of Motherwell, N.B. It is announced that the machine has been remodelled, and it would seem certain that considering Mr. Hurd's long experience and first-hand knowledge of the practical requirements for coal-cutting machinery, the new model should be thoroughly up to date and mark another stage in the advance of electric coal-cutters.

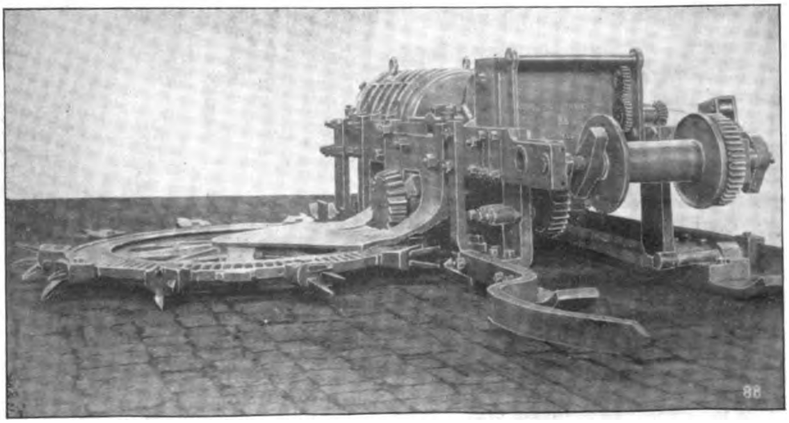


Fig. 21. Diamond Longwall Machine as in Fig. 20, arranged to Cut at Floor Level.

Machines of all three types, disc, chain, and bar, are made by the Diamond Coal Cutter Company of Wakefield, who are thus in a position to supply the most suitable type for any service. The diversity of machines manufactured by individual firms is proof of the fact that no one class of cutter will fulfil all conditions of working, and it may be taken that when the Diamond Company compares the relative advantages of their several machines for various services one is likely to get a fair idea as to the merits of the various types. Moreover these people make machines for compressed-air driving as well as electric coal-cutters for both direct-current and alternate-current circuits. In general it may be said that this firm advises disc machines for hard cutting, and where the coal is strong enough to hold up well when undercut; chain machines where the coal is tender and liable to settle; the bar machine also is suitable for the softer grades of coal.

The ideal seam for coal-cutting is perhaps one having a good roof, not less than 2ft. of coal, and below this not less than 8in. of holing dirt with a clean parting from coal and floor. In such a case the cutters remove the top 5in. or 6in. of dirt next to the coal, leaving a small bench for the débris to fall over, and this bench can easily be got up after the machine has passed, by means of the shovel.

In thin seams having no underclay and a hard floor or pavement it is often necessary to make the cut at floor level, removing as little coal as possible in the process. In such cases a less depth is advisable, say 4½ft., as the cuttings have a tendency to work back and clog the cutters.

Limitations of space prevent the inclusion of a full description of the several Diamond coal-cutters. Their general form is

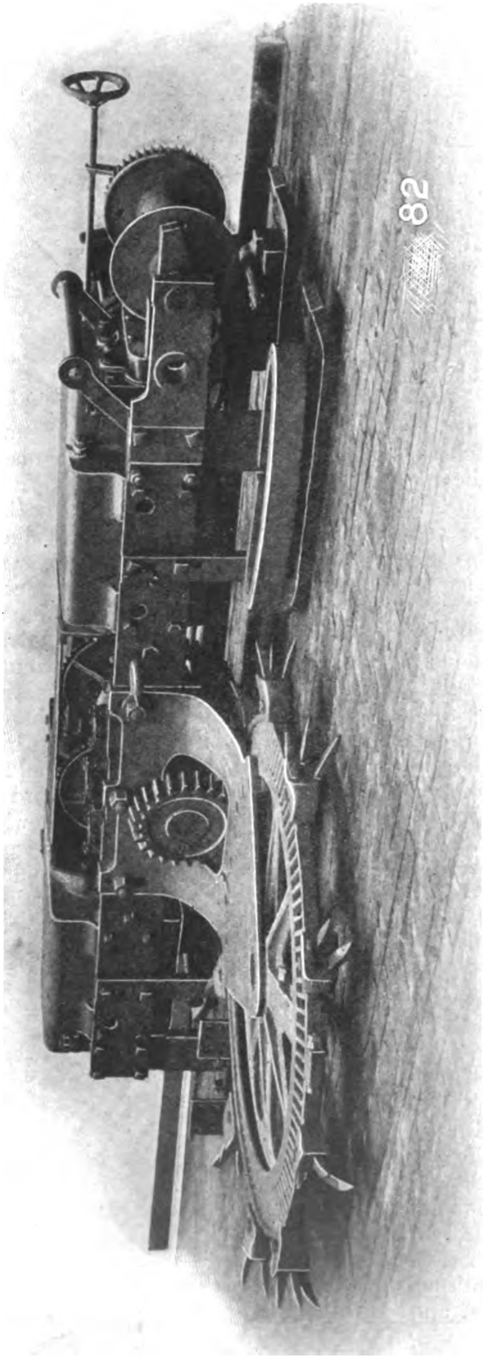


Fig. 22. Diamond Longwall Disc Machine for Direct-current Circuits, with Enclosing Covers removed.

well shown by the illustrations, Figs. 20 to 22.

Many interesting statistics have been published from time to time regarding the performance of the Diamond electric coal-cutters. The most remarkable economical results are naturally got in very thin seams which in many cases could not be profitably worked by hand. At a Yorkshire Colliery a seam of good house coal 19in. thick cost by hand 6s. 6d. per ton to fill and the average output was 18cwt. per man per day. Most of the coal was reduced to small in holing, the underlying dirt being too hard for the pick. By the introduction of a Diamond 5½ft. electric machine, holing in the dirt, the fillers' price was reduced to 3s., and the output per man increased to 3½ tons, besides all the coal being got in a saleable size.

* * *

Electric Coal Drills.

Considerable progress is being made in the adaptation of electric power to the driving of coal and rock drills. Until quite recently the compressed-air machine was almost universally used, and for very hard materials there can be no doubt that percussive drills, which lend themselves so readily to an air drive, are essential. Even for this hard service, however, electricity is available, and the percussive electric rock drill of the Sandycroft Company has become firmly established as a simple and efficient machine.

The Marvin-Sandycroft drill, as made by Messrs. The Sandycroft Foundry Company, Ltd., is of very simple construction, there being only two moving parts, viz., the plunger, which is a solid steel forging reciprocated by the alternate attraction of the two coils of wire surrounding it, and the rifled bar, which causes the partial rotation of the plunger after each blow. The coils are enclosed in a steel case, and are insulated by mica only, and therefore cannot be burnt out. There are no sliding contacts on the drill, the shifting of the current from one coil to the other to produce 385 strokes per minute being done entirely by a special electric generator. The current is conveyed to the drill by three wires, which may be tapped at any point of the line, thus giving extreme flexibility of working.

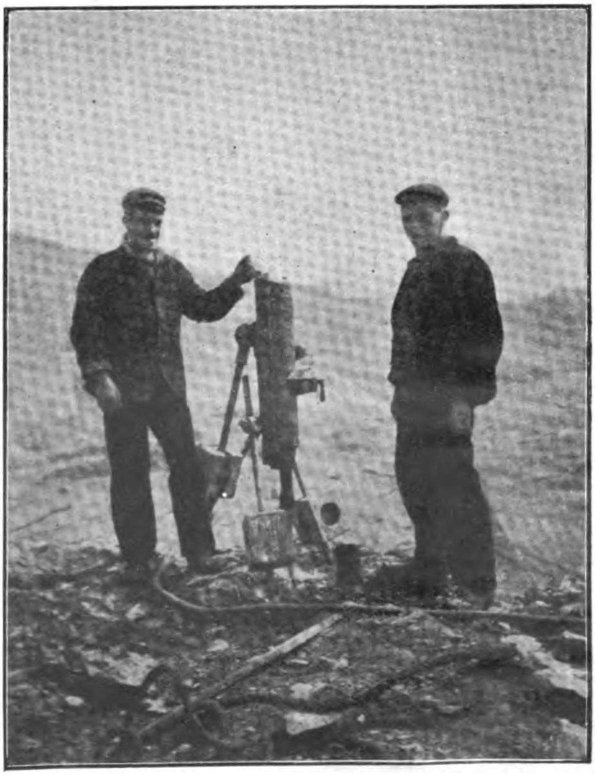


Fig. 1. The Marvin-Sandycroft Reciprocating Electric Drill.

The absence of motors, gearing, flexible shafts, air-tight fits, packed glands and valves renders this drill extremely simple and reliable. Although it is now almost five years since the first Marvin-Sandycroft electric rock-drill plant was installed in this country, it is claimed that not a single coil has given trouble in any way, there not

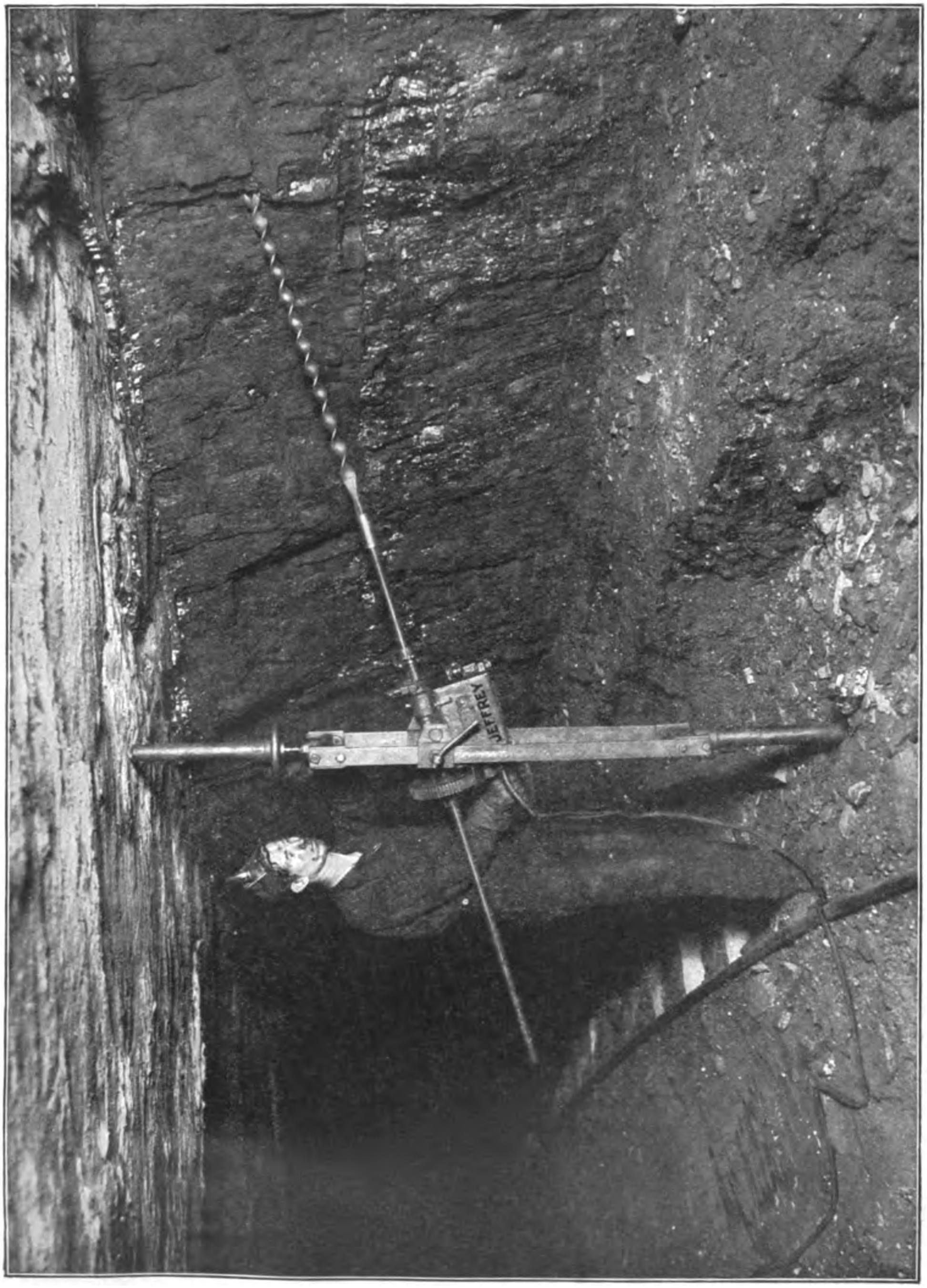


FIG. 2. THE JEFFREY ELECTRIC COAL DRILL IN USE.

having been a single instance of failure of insulation.

For the drilling of shot holes and for exploration purposes in coal, the simple twist drill has proved to be amply sufficient and extremely convenient in its lightness and portability.

The Diamond Coal-Cutter Company's electric drill shown in Fig. 3 is fitted on a Waterhouse patent carriage and is capable of drilling a 1¾in. hole. It is driven by an electric motor suitable for 400 to 500 volts. A starting switch with automatic overload and no-voltage release is fitted to the stand. The feed nut is of the split type and is furnished with a brake which is readily adjusted while the machine is at work. The stand is mounted on flat wheels or skids and can be easily drawn along the coal face by one man. The motor and drill are mounted in a revolving stand and can be readily set to bore at any required angle.

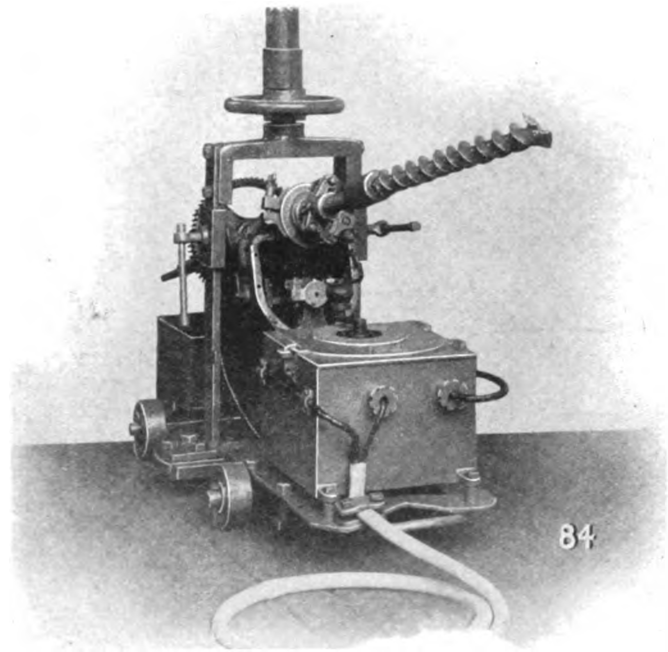


FIG. 3. . THE DIAMOND COAL DRILL ON WATERHOUSE CARRIAGE.

The fixing of the machine in position is the work of a moment, and various lengths of serrated pipe are provided in the tool box to suit the roof. Three drills are provided to bore to a depth of 5ft. In a 2ft. seam shot holes had to be bored 7ft. apart on a 500yd. longwall face to bring down the coal after the cutter, over 500 holes being bored per week. The cost of boring the holes 4ft. 6in. deep by hand cost 5d. per hole; by the use of these drills the cost was reduced to 1¾d. per hole, this representing a saving of over 1½d. per ton.

The Jeffrey electrical coal drill as supplied by Messrs. John Davis & Son (Derby), Ltd., is of strong and light construction. The frame is made in different lengths to suit the various seams, and is fitted with a hand-wheel for fixing it between the pavement and roof, as shown in the illustration Fig. 2. The body of the drill can be mounted on trunnion brackets with hinged lids, so that it may be readily unshipped for moving about the pit. The brackets slide up and down the sides of the frame, and the drill may be put in any vertical direction within a range of more than 90deg. The drill complete with frame weighs about 180lb. The motor is series-wound, and the connections are made by cable sockets fitted with a bayonet arrangement. The thrust is taken up by a ball race on the front of the machine, and to this is connected a slipping clutch in case the drill should meet with any serious obstruction. Three drill bits are supplied, and when drilling in coal a hole 2in. diameter and 6ft. deep can be finished in about 2½ minutes, including the changing of the drills. Exploration holes for approaching water are also bored in coal with these drills 21ft. deep, 2in. diameter, being finished in about 55 minutes. When working in oil-shale, the drill does good work at the rate of 4ft. in about 2 minutes. A special truck is supplied to carry the whole of the drill and gear.

These drills are also used for working in rock, in which case they are fitted with a double-reduction gear to allow of a slower feed, and the machine as a whole is much stronger, weighing complete about 300lb. The normal feed on this duty is at the rate of 2ft. in 1½ minutes.

The machine shown in Figs. 4 and 5 has been specially designed for drilling in rock, stone, and other strata usually found in the coal measures. It is made by the Corlett Electrical Engineering Company, Ltd., and consists essentially of three parts: the drilling machine; the column, &c.; and the motor and telescopic shaft.

The drilling machine is of the rotary type, steel and a specially strong bronze being used almost exclusively in its construction. There are few moving parts and only one pair of gears, which are machine-cut bevel wheels. The drill spindle of special steel is threaded its entire length, the chuck being detachable. The thrust bearing is of the conical roller type, of great strength, and built for a working pressure of six tons. The feed gear is extremely simple, controlled by a brake, and is adjustable from $\frac{1}{10}$in. per revolution to zero. There are two feed adjusting screws, one on each side of the machine, for convenience in handling in cramped situations. The standard length of travel, without changing a drill, is 22in. The finished size of hole is 1¾in. All parts are enclosed and work in oil. Drills of special steel of twist pattern are used.

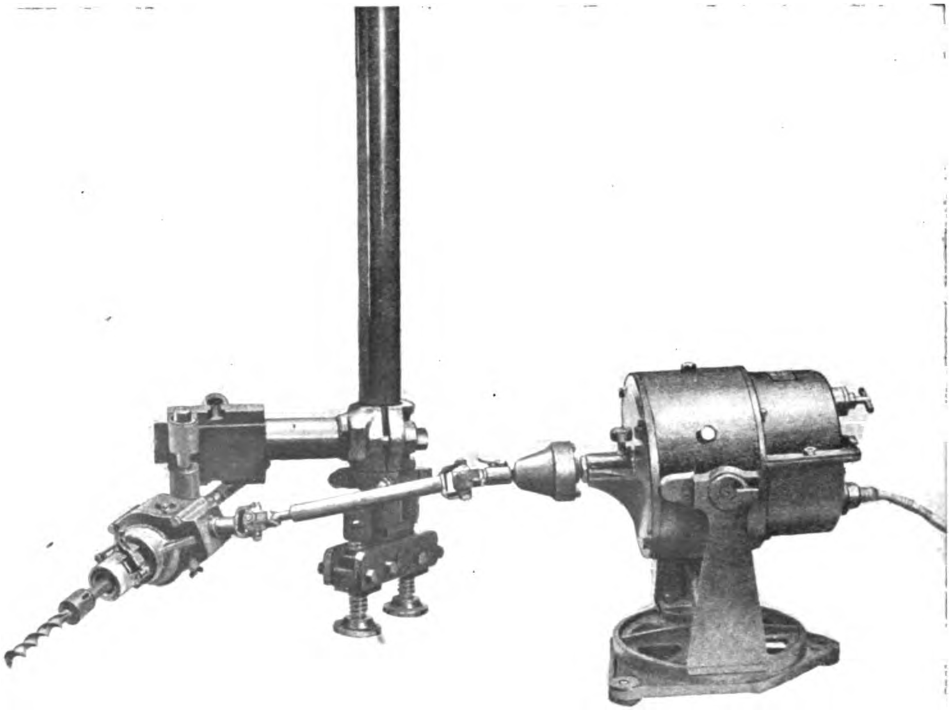


Fig. 4. The Corlett Electric Mining Drill.

The electric motor may be either of the continuous-current or the polyphase type of 4b.h.p., fitted with trunnions for fixing to a revolving turn-table, with flat base for fixing to ordinary flat-topped colliery tram. The motor can be tilted at any angle, and a friction clutch is fitted on the spindle, which can be set to slip at any desired overload. It runs at a slow speed, allowing the telescopic shaft to be attached direct to the spindle. The standard continuous-current motors are series-wound, suitable for 110, 230, or 500 volts, and are gas- and waterproof. The controlling switch is fitted in a gas-tight case, and is provided with magnetic blow-outs. The standard alternate-current motors are of the short-circuited rotor type, wound for 500 volts, 40-period, three-phase. The weights of the complete equipment are: drilling machine 120lb.; clip gear 75lb.; column and arm 280lb.; motor 600lb.; telescopic shaft 20lb.

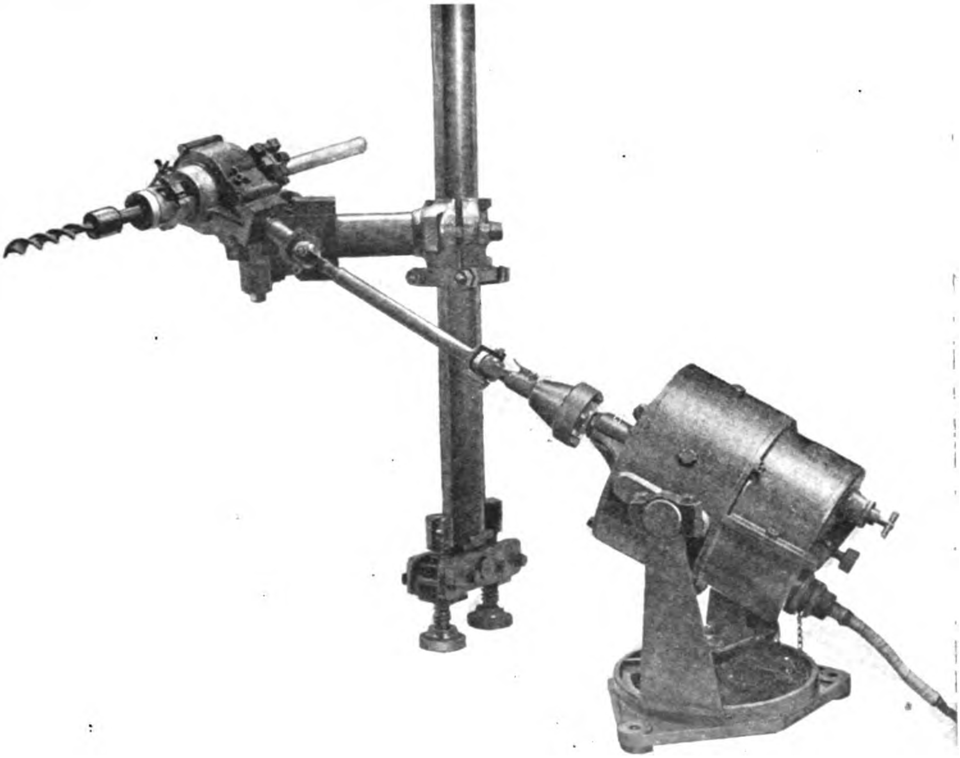


Fig. 5. The Corlett Electric Mining Drill.

The speed of drilling naturally varies with the nature of the ground, but from figures obtained by a plant worked by the ordinary staff at a colliery, on day wage, driving a tunnel 12ft. by 6ft., a round of holes, each 6ft. 6in. to 6ft. deep, finished diameter 1¾in., can be drilled, and all the tackle cleared away ready for shot firing in three hours; and in another drift, 15ft. by 8ft., 13yd. have been driven in one week. The cost of a tunnel is largely reduced, and what is of far greater importance, the rate of progress is increased enormously. The machines have been in practical use for over three years, and are working at many collieries in all parts of the country.

The construction of a percussive type of electrical drill made by Siemens is shown on the cross-section drawing, Fig. 6. It consists of a main reciprocating drill bar, which is driven by a connecting rod and cross head from the motor countershaft, heavy spiral springs being interposed between the cross head and the drill bar. The drill bar has cut upon it a screw thread working in a nut free to revolve in one direction so that a rotary motion is imparted to the drill during its forward movement. The machine is provided with a hand-feeding arrangement, having a total range of about 2ft. 6in. The drill strikes from 400 to 500 blows per minute.

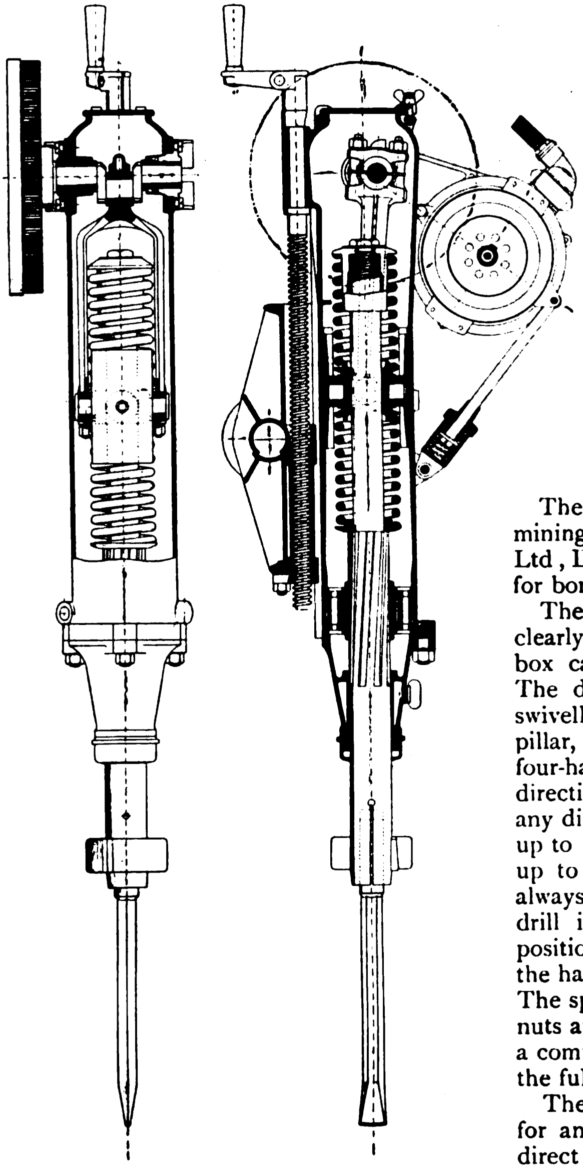


Fig. 6.
Siemens Reciprocating Electric Drill.

The motor is mounted directly upon the drill frame and drives the drill through single-reduction spur gearing. The motors are wound for three-phase or continuous current not exceeding 300 volts; the makers recommend the three-phase current as preferable.

Combined with the motor is a suitable starter and friction clutch, the former being so arranged that the motor is first started light and allowed to attain full speed, the clutch being afterwards thrown in. The drill is thus brought gradually up to speed. The clutch also serves to screen the motor from sudden shocks and overloads, a suitable spring device being provided in the clutch for adjusting it so that slipping will occur at a predetermined overload.

The drills are built in two sizes, fitted with 1h.p. and 2h.p. motor respectively. The smaller size is provided either for use with an extension column or mounted on a tripod. The larger size is used mainly for heavy work; it is not supplied with an extension column, but generally with a frame, on which two or four drills are mounted for tunnelling work.

The "Crescent" coal drill is another mining speciality of Messrs. A. Hirst & Son, Ltd, Dewsbury. This drill is made specially for boring shot-holes at the tops of seams.

The general form of the machine is shown clearly in Fig. 7. It is built up on a steel box carrying the motor and the gearing. The drill spindle is fitted in a universal swivelling head fitted to the top of a screwed pillar, this latter being provided with a four-handled-nut for adjustment in a vertical direction. The drill can be set to bore in any direction radially; upwards at any angle up to 30deg., and downwards at any angle up to 20deg., and the driving wheels are always in full gear whatever direction the drill is set to. The machine is held in position by being jammed up to the roof, the handled-nut being used for this purpose. The spindle is provided with a pair of clasp nuts and a friction feed device which gives a complete range of speed from zero up to the full pitch of the feed screw.

The motor is of 2h.p. and can be supplied for any voltage up to 600, and for either direct or alternating current. The whole machine is self-contained, runs on four travelling wheels, weighs about 3½cwt., and is very easily moved about.

When holes of greater depth than 4ft. are required, the machine is fitted with a hollow spindle, in which case the drill proper is only a very short one and is fitted to a wormed drill shank which slides through the hollow spindle. This shank is made in lengths of about 2ft. 6in. each and any number of them can be attached as the drill proceeds.

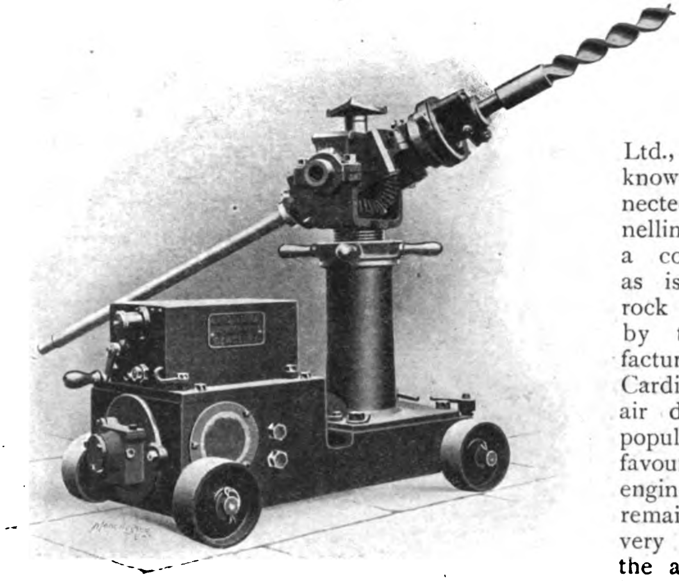


Fig. 7. The Crescent Coal Drill.

On a longwall face the machine drills fifty-five to sixty holes in six hours, each hole being 4ft. deep by 2in. diameter.

The "Little Hardy" rock drill, by the Hardy Patent Pick Company, Ltd., Heeley, Sheffield, is known to everybody connected with mining, tunnelling, or boring. It is a compressed-air machine, as is also the "Murphy" rock drill which is supplied by the Goodman Manufacturing Company, Ltd., Cardiff. The compressed-air drill is still certain of popularity — it is an old favourite with all mining engineers and is likely to remain so for working in very hard rock. But even the air drill is of little use in collieries without electricity: the compressors for the drill supply must be electrically driven to secure economical and reliable working.

Auxiliary Electric Power Appliances and Accessories.

Given an electricity supply, there are a hundred and one means of gaining economies in and about a colliery. In the way of power applications of the current not previously dealt with in this number are the driving of ventilating fans, all classes of pit-head gear, screens, crushers, elevators, cranes, capstans, locomotives, coke-oven chargers and rams, workshop tools, small ventilators, &c., &c. It is not possible to enumerate or describe here the many duties which electric power now undertakes in coal-mining. The illustrations herewith have been selected as indicating to some extent the range covered, and they practically each tell their own story without the necessity of lengthy description.

The shales from most pits are well adapted for being made into building bricks, and many collieries find brickmaking a very profitable undertaking. The shale being otherwise a waste and generally containing some bituminous matter (almost sufficient to burn the bricks without additional fuel) puts the colliery owner in the position of being able to produce his bricks much cheaper than the ordinary brickmaker.

When a red-burning shale is being dealt with, some care must be taken to ensure that it does not contain too much coaly matter, otherwise the bricks would be melted in the kiln owing to the difficulty of obtaining an oxidising flame, but, generally speaking, when it is desired to make bricks from such a material, little difficulty is experienced in choosing the cleaner lots of shale that come to the surface. Old tips of red-burning shale are not very suitable for brickmaking, as they generally contain too much coal. When the débris consists of fire-clays this objection does not hold. For instance, in the Scotch coalfields great quantities of bricks are being made from old tips.

The best system to adopt is to allow the shale a few weeks' exposure to the weather before treatment. It is then ground to a suitable fineness in a perforated edge runner grinding mill, arranged to work in conjunction with an elevator and screen. The fine material

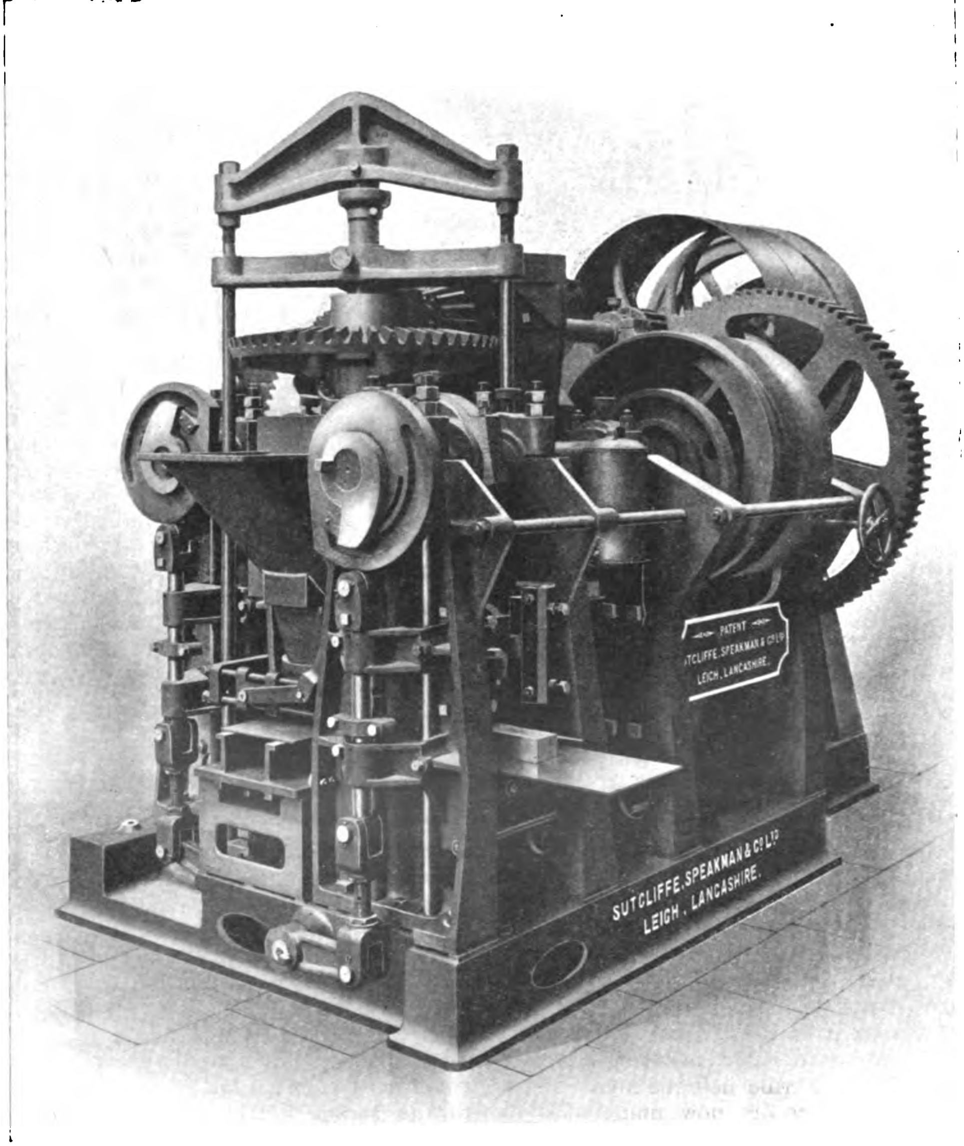


Fig. 1. Brick-making Machine, suitable for Electric Driving, as used for Making Bricks from Colliery Shale.

then passes to a differential mixer, where it is moistened, and thence to the brickmaking machine. The one illustrated in Fig. 1 is a modern machine on the stiff-plastic principle; that is to say, it combines the principles of the soft plastic wire-cut machine and the semi-dry machine inasmuch as it makes the bricks in a pugmill and then automatically presses them, delivering them of a stiffness suitable for sending direct to the brick-kiln. It is a high-capacity machine of great strength, weighing about 20 tons, its capacity on ordinary shales being 2400 per hour, but on colliery shales the makers recommend an output equal to that of a 9ft. perforated grinding mill, namely 1600 to 1800 per hour.

The kiln used should be a continuous one of the Hoffmann type. Such a kiln will burn bricks made from colliery shale with as low as 1 to 2cwt. of small coal per 1000 bricks.

Messrs. Sutcliffe, Speakman, & Co., Ltd., of Leigh, Lancashire, have such a plant in operation at the works of Messrs. John Speakman & Sons, Bedford Colliery, Leigh, Lancashire, and the quality of the bricks is such that they were specified and used for facing the new Leigh Infirmary opened the latter part of last year.

They have other plants and machines erected, including one at a colliery in the north of France, and they have now a contract for a South Wales colliery where the whole installation will be operated by electricity.

With reference to the illustration Fig. 2 of the electrically driven pneumatic hammer, a speciality of Messrs. B. & S. Massey, it should be noted that many important advantages are gained where it is possible to drive each hammer by a separate electric motor. There is great economy of power, for where hammers are belt-driven it is necessary to keep heavy shafting and belts running continuously although the hammers themselves are only required intermittently. It may be thought that the power thus absorbed is small compared with the power actually used in driving the hammer, but this is not the case, as the following instance will show. In a ten days' test (96 working hours) in a very busy smithy containing three hammers, 5cwt., 7cwt., and 10cwt. respectively, each driven by its own motor, the total power consumed was 859 Board of Trade units, or just under 3 units an hour, or 30 units a day for each hammer. This represents an average load during working hours of $10\frac{1}{4}$b.h.p.

Now were three similar hammers to be driven by belt, the shafting, &c., necessary would have to be capable of transmitting at least 60h.p. in case all the hammers should

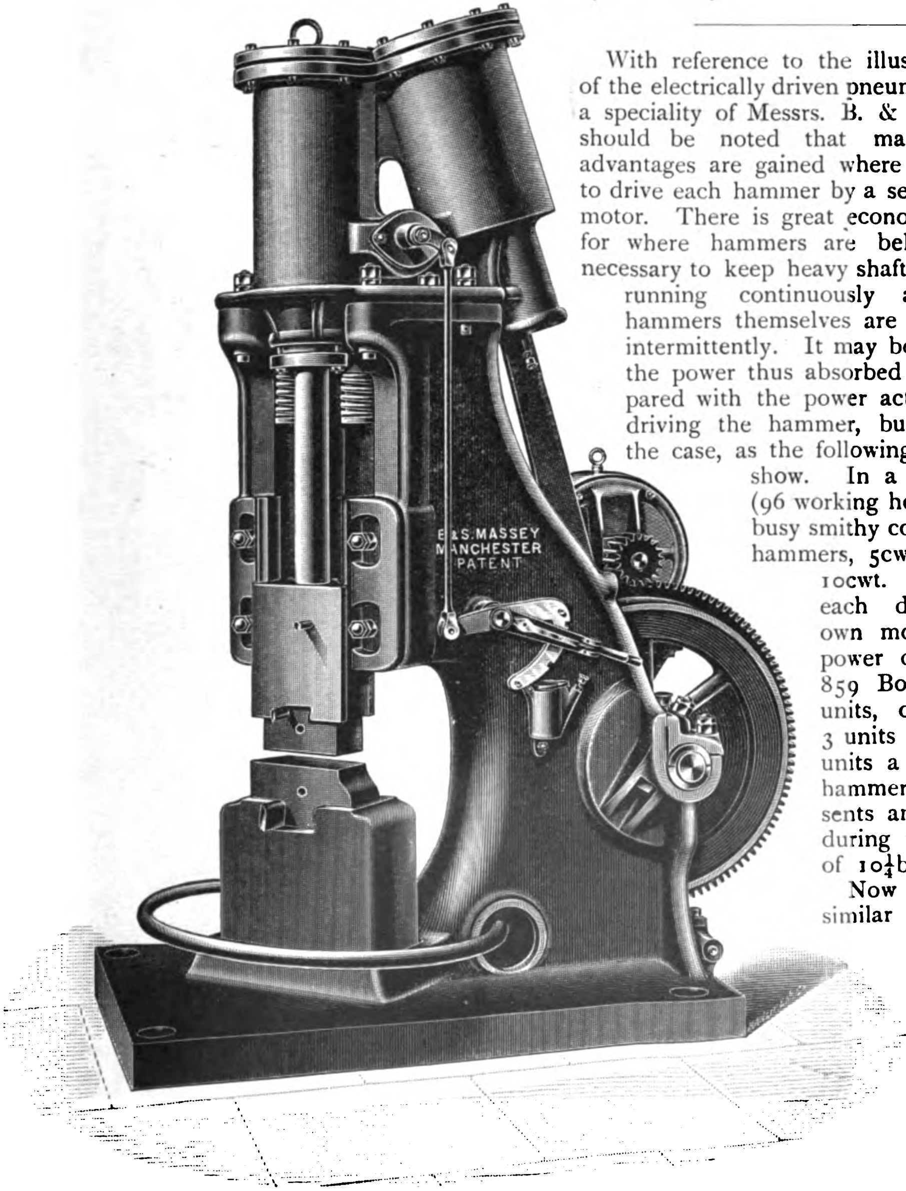


Fig 2. The Massey Electro-Pneumatic Hammer.

happen to be striking their hardest blows at once, and such powerful shafting, with the necessary heavy belts, would not generally take less than 7h.p. to drive. Thus the shafting would cost about two-thirds as much to run as the hammers themselves; or, assuming the shafting itself to be driven by a large electric motor and current to cost 1d. per unit, the three hammers themselves would cost 2s. 6d. per day each to drive and the shafting 5s. per day.

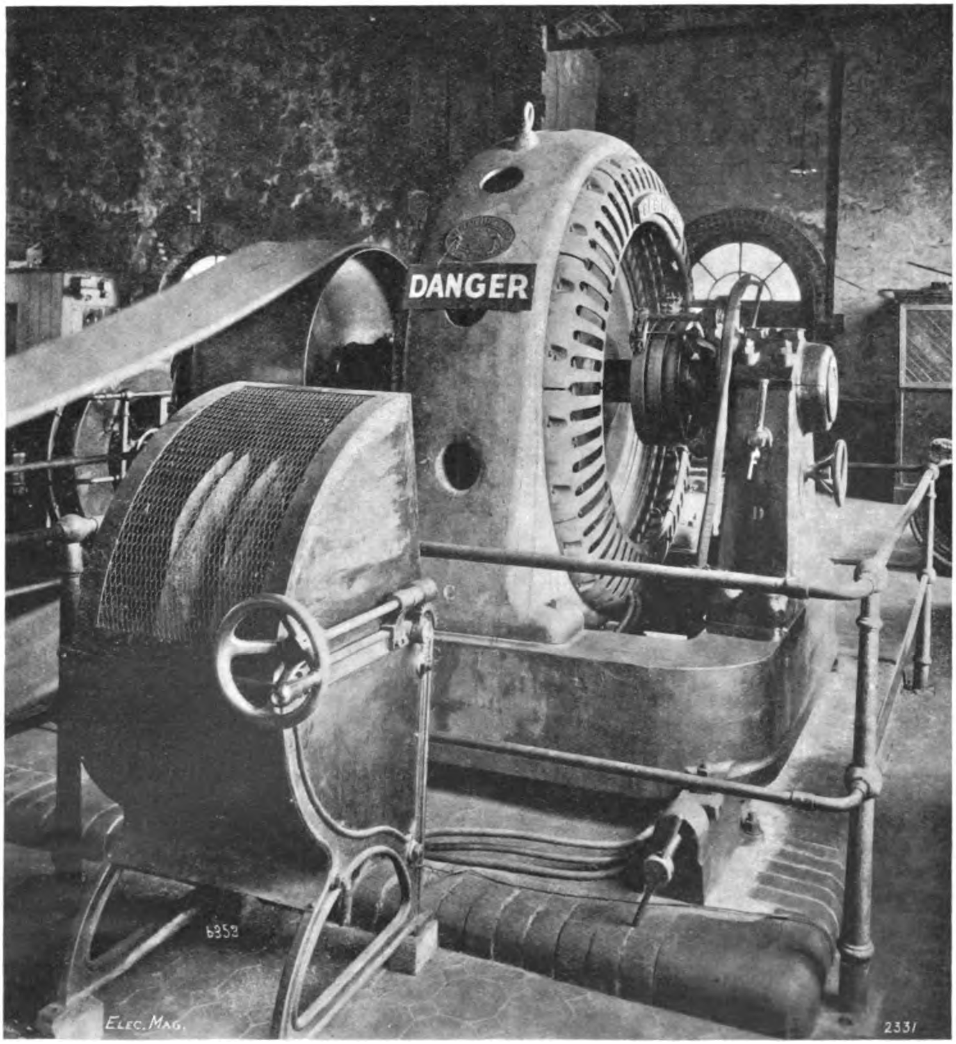


FIG. 3. 225H.P. THREE-PHASE MOTOR DRIVING COLLIERY FAN (GENERAL ELECTRIC COMPANY, LTD.).

Hammers so arranged can be placed anywhere without reference to the position of engines, shafting, &c., and can thus often be used to greater advantage than when the choice of position is restricted to places where a belt drive is convenient. The absence of belts enables cranes to be used over and on all sides of hammers. A single hammer can be used by itself when the rest of the machinery is standing, often a great convenience for overtime or night work.

In the case of the hammer illustrated the motor is mounted on a strong bracket, securely fastened to the standard, and drives the hammer direct by means of a raw hide pinion working into machine-cut teeth on the flywheel.

As makers of high-grade steel winding and haulage ropes for colliery service there is no firm better known than Messrs. Glaholm & Robson, Ltd., of Sunderland, whose new works are rapidly nearing completion. It will be remembered that a destructive fire took place at this firm's Hendon patent-wire-rope works on September 15th last, when about £15,000 worth of damage was done. Fortunately, it was the old portion of the works which was burnt out, and as the new north and east wings, with machinery, were both saved, Messrs. Glaholm & Robson have been able by working night and day shifts to keep most of their customers supplied.

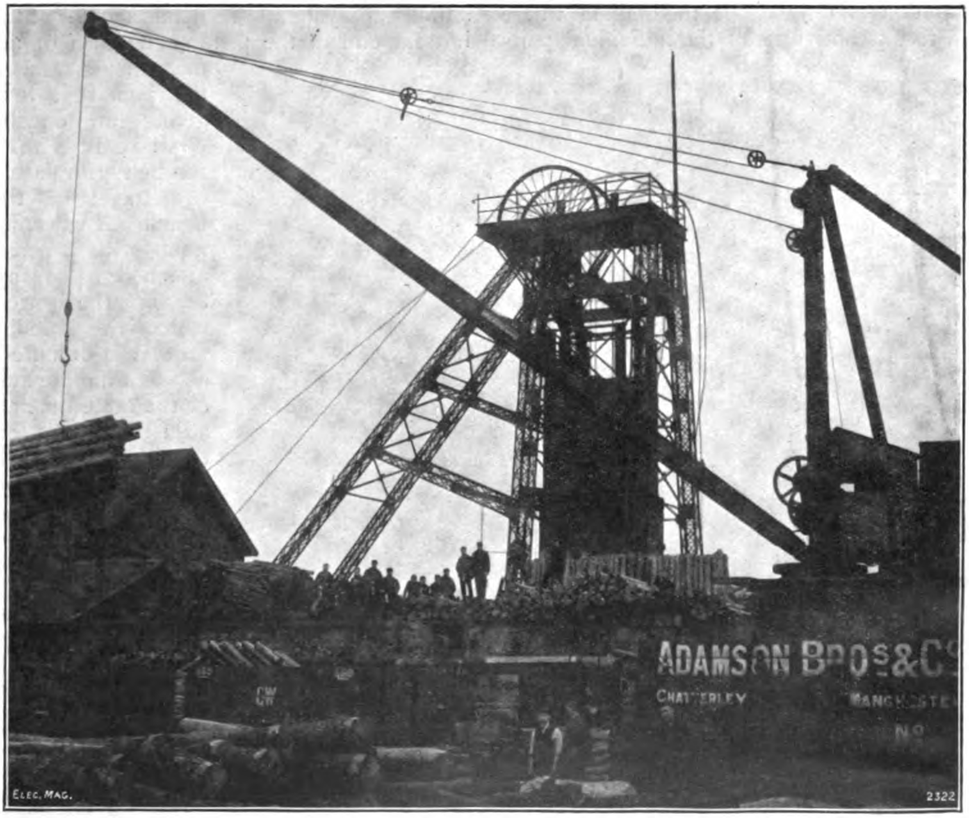


Fig. 4. An Electric Crane for General Colliery Service (Royce & Co. Ltd.).

The new works, which are close to the railway and will be known as the Railway-Side Works, are two storeys in height, the ground floor being 17ft. 6in. to the underside of the girders, and the first floor, which has an open iron-framed roof, about 30ft. to the ridge.

The works cover a space of about 300ft. by 60ft., and are fitted with electric travelling crane and hoists, and the power will be supplied by gas engines working on suction gas.

As nothing but the very latest machinery and appliances for the efficient and economical manufacture of wire rope is being installed, Messrs. Glaholm & Robson hope shortly to be in a position to take up new business on terms mutually advantageous to wire rope buyers and themselves. They manufacture the highest qualities of plain and galvanised haulage and winding ropes for mining purposes; special flexible and extra special flexible steel wire ropes, plain, galvanised, or plated, for crane and general engineering purposes; galvanised flexible and special flexible steel-wire ropes, guaranteed to Lloyd's and Admiralty tests for shipping purposes.

At the present moment they have a Government contract in hand for the British Navy, and have very recently executed orders from Colonial, the Indian, and foreign Governments.

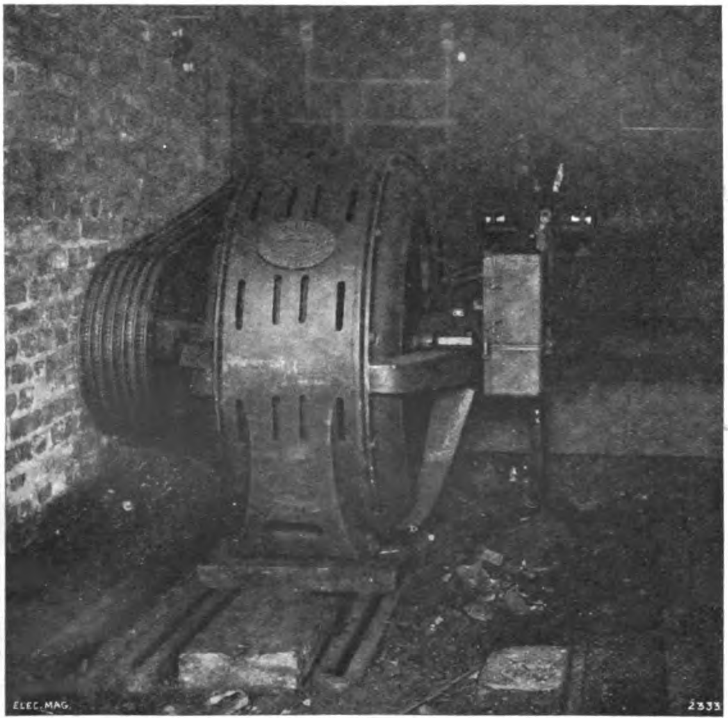


FIG. 5. 150H.P. THREE-PHASE MOTOR DRIVING CENTRIFUGAL PUMP BY ROPES (GENERAL ELECTRIC CO., LTD.).

The greatest degree of economy in plant operation is only to be maintained where full results and tests of the individual parts of the complete installation are habitually made. A very large business is being done with collieries by Messrs. Hannan & Buchanan of Glasgow, who make a speciality of power indicating and recording instruments. This firm has recently introduced a new line of improved Thompson system indicators. These are made in three different types, and are all sheathed with vulcanite, to protect the hands while in use. The parallel motion is very compact and light, consistent with strength. It is fitted on the swivel arm by two swinging fulcrums, the one near the middle adding to the stability of the motion, as well as aiding to procure a perfectly parallel line throughout the entire travel. The pencil arm is immediately over the piston rod, thus preventing any side thrust; it is also connected to the piston rod, by a ball and socket joint, which reduces friction and momentum. The movement of the pencil is a multiple of six times that of the piston, and by applying a special micrometer at the bottom end of the piston, one turn of the micrometer raises the pencil $\frac{1}{6}$, thus giving an equally divided scale throughout the entire travel of the pencil. A vulcanite knob with a screw attached, passing through the arm on which the parallel motion is mounted, acts as a handle and at the same time an adjusting screw, so that the pressure of the pencil on the paper drum can be adjusted to a nicety. The drum is of the usual light pattern, fitted with spiral spring, and means are provided for adjusting the tension to suit the various speeds.

These instruments can also be fitted with Buchanan's patent lubricating piston, which takes the form of a small cup, with annular grooves cut on the outside, into which a number of small holes are bored, to allow the lubricant to come in contact with the walls of the cylinders, thus producing an oil packing. It also acts as a receptacle for grit, which it retains until the test is completed. This patent piston can be supplied in steel or gun metal, and is fitted with a tubular steel piston rod, which ensures lightness and strength.

Some Typical Colliery Installations.

*The Aberdare Collieries of the Powell Duffryn Company.**

CHARLES P. SPARKS.

THE group of collieries dealt with in this paper are situated 20 miles north-west of Cardiff; they have been worked by the Powell Duffryn Company since 1864, and are raising 1,250,000 tons of coal per annum.

Before the present electrical scheme was put in hand six of the nine pits had isolated direct-current plants generating at 200 or 400 volts for lighting and power purposes.

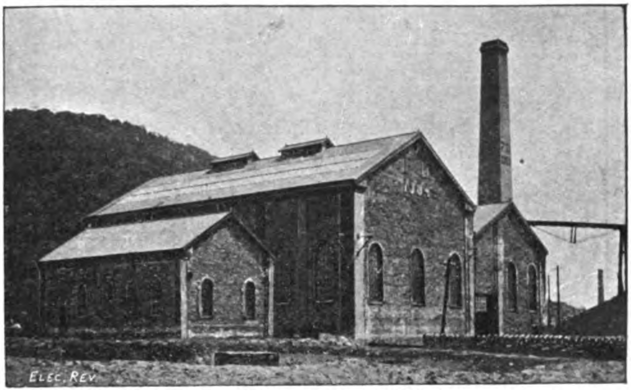
In place of extending these plants for the more general use of electric power, it was decided to erect a power station to supply the whole of the company's pits in the Aberdare Valley, to obtain the advantage of a higher load factor by concentrating the generating plant in one power house, instead of having plant, together with reserves, capable of dealing with the maximum power required, at each pit; the direct result being to lower the capital and generating costs, due to the decreased amount of generating plant required, the lower cost per kilowatt, and the greater economy of the larger units assembled at a single power station.

The district served is eight square miles in area, some points being four miles from the proposed power station; and as a considerable demand for power might develope at any point in this area, it was decided to use the three-phase system at 50 periods, 3000 volts, with overhead transmission lines, the existing d.c. motors being utilised by grouping nineteen motors of 210b.h.p. at one pit and driving them from the three-phase system by a motor generator supplied at 3000 volts.

The electric power is being supplied to seven of the pits from a power station which has been erected close to the coal washery, and approximately central to the area to be supplied.

The scheme was projected in 1903, before the issue of the Home Office Regulations for the use of electricity in mines, and a contract for the whole work given to the Electrical Company in the autumn of the same year. The power station was started and the first motors put to work in May, 1905.

Owing to the nature of the business the drives could only be gradually transferred from steam to electric, and at the end of 1905 some 4600b.h.p. of motors were at work out of a total of 6000b.h.p.



EXTERIOR VIEW OF GENERATING STATION NEAR MIDDLE DUFFRYN, ABERDARE VALLEY.

The total h.p. at present in use at these collieries amounts to 12,170, and whilst the most uneconomical drives, amounting to over one-third of the total, have been converted from steam to electric driving, resulting during December, 1905, in putting 25 Lancashire boilers out of use, displacing the boiler plant entirely at five points, 32 Lancashire boilers 30ft. by 8ft., or their equivalent, still remain driving the balance of 7570h.p. Now that the power station has been started there is little doubt that, as occasion arises, a large part of the remaining steam plant will be superseded by electric driving.

The present records show the colliery requirements to average 1000 units per annum per b.h.p. erected, with a load factor on the power station of 37 per cent. Were the whole of the driving electric, the output

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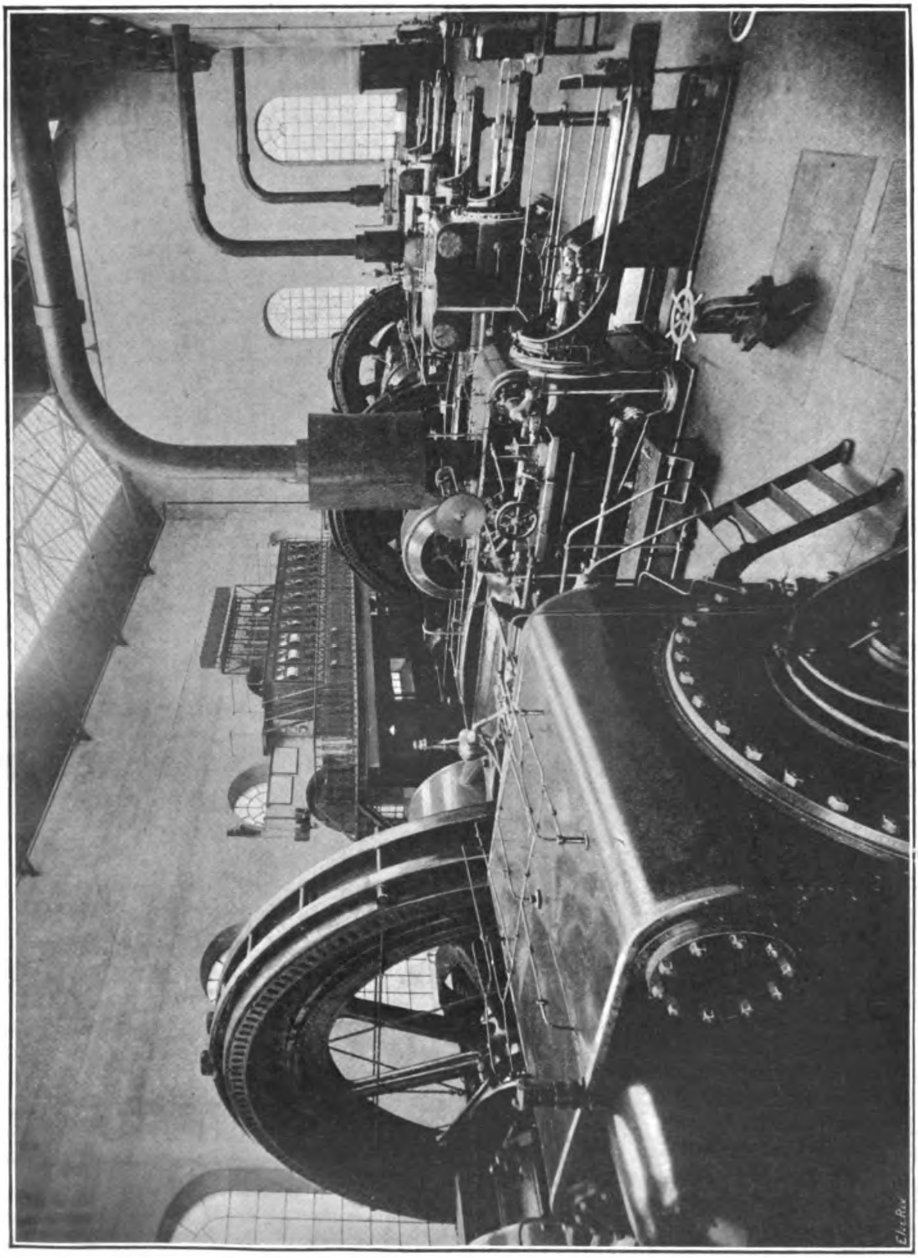
*Abstract of Paper read before the Institution of Electrical Engineers, March 22, 1906.



View in the Engine Room, Aberdare Collieries, showing 1500kw. Set in the Foreground and Two 750kw. Sets in the Background, with General View of the Switchboard and Lightning Arresters.

of the power station would be about twelve million units per annum, the load factor on the station would be between 40 and 50 per cent., the latter figure being reached should pumping be confined to the hours when the haulages are not at work. Ten units would be required for all power purposes per ton of coal raised with the present output of 1,250,000 tons per annum.

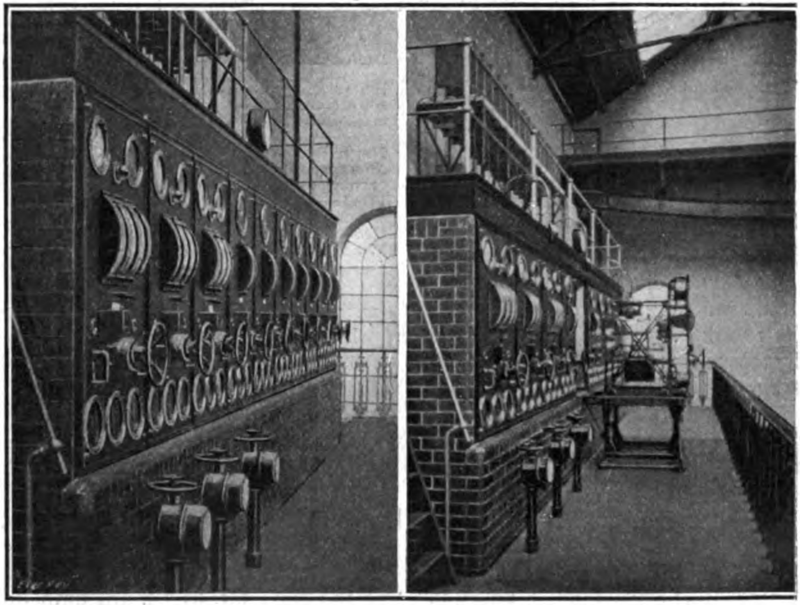
The power station is equipped to deal with an average load of 1500kw., this demand being met either by one 1500kw. or two 750kw. sets during the day, and one 750kw. set during the night and on Sundays.

The alternators, one of 2000k.v.a. and two of 1000k.v.a., are three-phase star-connected (with neutral earthed). The regulation of these machines is six per cent. on non-inductive and sixteen per cent. on inductive load, 0.75 power factor. The field magnets are carried by the engine flywheel, the machines being mounted between the cylinders of slow-speed engines; excitation for each set is provided by a rope-driven exciter (110 volts).

The engines are horizontal, cross compound, jet condensing, made by Yates & Thom, of Blackburn. They are governed on both high and low pressure cylinders so as to carry momentary overloads of 50 per cent. The air pumps on the larger set are of the Edwards type, driven from the tail-rod of the high-pressure cylinder.

The parallel running of these sets is satisfactory under all conditions, while the steady pressure of supply gives satisfactory results in starting and running the largest motors under heavy overloads without interference with the general good working of the system.

Steam is supplied from Babcock and Wilcox boilers, each having a grate area of 49 square feet, heating surface 3080 square feet, with 350 square feet of superheating surface, five boilers being used at time of maximum load.


(1) (2)

MAIN SWITCHBOARD. (1) END VIEW. (2) END VIEW WITH ONE PANEL WITHDRAWN ON SPECIAL CARRIAGE FOR INSPECTION.

The boilers are set in pairs and are hand-fired with unwashed small coal, the fuel being delivered from overhead bunkers filled by a bucket conveyor. The feed is heated by a Green's economiser. Water for condensation is obtained from a reservoir directly connected with the river.

The switchboard is of the carriage type of cellular construction with the bus bars running along the back in a separate chamber, from which contacts project into each division. The whole of the switchgear, instruments, and transformers for each panel are mounted on a carriage which can be withdrawn as a whole on to a trolley should any adjustment become necessary. With the panels in position the exterior of the board consists of brick or earthed metal work. This system is a safe one for the employees, as no adjustment can be made on the working parts of the switchgear unless it is dead, the panel being only movable when the main switch is in the "off" position.

All panels are equipped with three-phase oil-break switches, fitted with over-load relays, the machine panels having in addition reverse current cut-outs; synchronising is effected by a synchroscope. The machine panels have ammeter, wattmeter, and voltmeter; the circuits, ammeters and watt-hour-meters. The top of the board is enclosed and is used as a platform to obtain access to the lightning arresters and their resistances. These are protected by divisions, but are not enclosed.

The maximum demand reached during 1905 was 1400kw., momentary demands reaching 1750kw., this demand on the power station being one-third of that required to drive all the motors erected if they were run simultaneously at maximum load.

The output of the power station is at the rate of 4½ million units per annum, so that the load factor of the station when the original equipment of motors is completed will lie between 35 and 40 per cent., and when the percentage of pumps and fans driven electrically is increased, and the pumping confined as far as possible to the night, a load factor of over 40 per cent. will be reached.

Tests of the power station show a fuel consumption with unwashed small coal having a calorific value of 13,000b.t.u., with the sets operating at full load, of 2.7lb. for the 1500kw., and 3lb. with the 750kw. sets, the weekly coal figure per unit delivered to the transmission lines averaging 3¾lb. of the above coal with an output varying between 87,500 and 92,000 units per week.

The transmission lines are designed to supply 6000b.h.p. of motors, based on a motor efficiency of 87 per cent., power factor 75 per cent., with a maximum drop of 10 per cent. in pressure with 70 per cent. of the motors working at full load simultaneously at any individual point.

The table below gives the distance between pits and the power station, the cross-section of each feeder, and the b.h.p. of motors in use, the greatest distance to a centre of distribution (above ground) from the power station being 2¼ miles. As the conductors radiate three-quarters of a mile beyond this point, the longest transmission is 3 miles.

	Distance from Power Station in yards.	Cross Section Feeder. Square inches.	B.H.P. of Motors Supplied, Dec., 1905.
Lower Duffryn	1870	.08	1131
Abercwmboi	1930	.04	205
Old Duffryn and Lletty Shenkin	620	.11	561
Upper Lletty Shenkin ..	1268	.04	441
Aberaman	1325	2 × .15	960
Cwmneol	2715	2 × .15	316
Fforchaman	3770	2 × .15	821
Treaman	—	—	—
George	—	—	—
Washery (Power Station) ..	—	—	105
			4540

In addition the lighting load above and below ground amounts to 125kw.

The overhead transmission lines are bare hard-drawn conductors, wires up to 0.042 square inches (4 S.W.G.) being solid, any wires over this size being stranded. The wires are supported on wooden poles, except at points of special strain, where lattice steel poles are used. The poles are creosoted, and average 33ft. long by 7in. in diameter at the top; 6ft. to 7ft. are embedded in the earth, and where the foundation is doubtful they are set in concrete. The poles are erected an average of 40yd. apart, the maximum distance in straight runs not exceeding 45yd. The wires are supported on porcelain insulators mounted on wrought-iron supports. The insulators are set at 12in. centres horizontally, and 18in. vertically, the wires being carried 20ft. from the ground level. Guard-netting is erected below the transmission lines at all points where existing wires are crossed, or in the vicinity of the colliery premises where there is traffic. This guard-netting consists of two steel wires, 3/16in. in diameter, stretched below the transmission wires with transverse ¼in. diameter wires every 6ft., the ends of the transverse wires being turned up to insure any broken wire being caught by the netting. Where guard-netting is not used, steel catchers are fitted at each pole to insure a broken wire striking the catcher thus becoming earthed. To prevent anyone climbing the poles they have barbed wire spiralled round them, and are further protected by having a ring fitted with spikes fixed on each pole 10ft. from the ground. At one point where the wire crosses a number of telegraph lines on a public road, the transmission wires are carried through a lattice bridge.

In addition to the transmission wires, the poles carry telephone wires connecting the power station and the various sub-stations; these wires are crossed every 200yd. to minimise induction.

The sub-stations are either separate buildings or rooms to which ordinary employees have no access. Each sub-station is fed from the power station by one or more high-tension feeders, which are protected at each end by lightning arresters.

Before connection to the sub-station bus bars the incoming feeders are controlled by oil break switches, and by fuses in the case of sub-stations fed by two feeders.

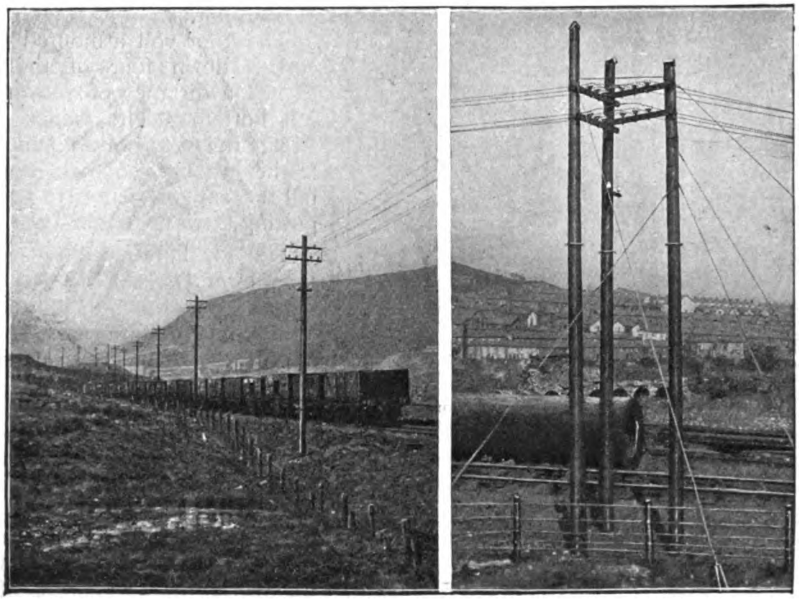
The sub-station bus bars branch to: 3000-volt sub-stations below ground, connected by armoured cables; 3000-volt motors connected by overhead distributors; three-phase transformers reducing the pressure to 500 volts (for motors below 50h.p.); and to single-phase 110-volt lighting transformers.

Each high-pressure panel for outgoing feeders or transformers is equipped with oil break switch, enclosed fuse, and series ammeter transformer, so that the demands on the individual circuits can be checked. The back of each panel is only accessible when the controlling switch is in the "off" position.

The low-pressure circuits have 3-pole enclosed fuses, combined with switches, arranged so that all exposed metal is dead when the switch is opened for the renewal of fuses. Each sub-station is provided with one voltmeter for each pressure and two ammeters.

The general arrangement of the underground sub-stations is the same as of those above ground, but in this case each panel of the switch-gear is placed in a separate brick compartment, closed by a lock-up metal case, the whole switchboard being independently roofed in. These sub-stations are placed close to the downcast shaft to admit of their being well ventilated.

The switch-gear in each panel consists of



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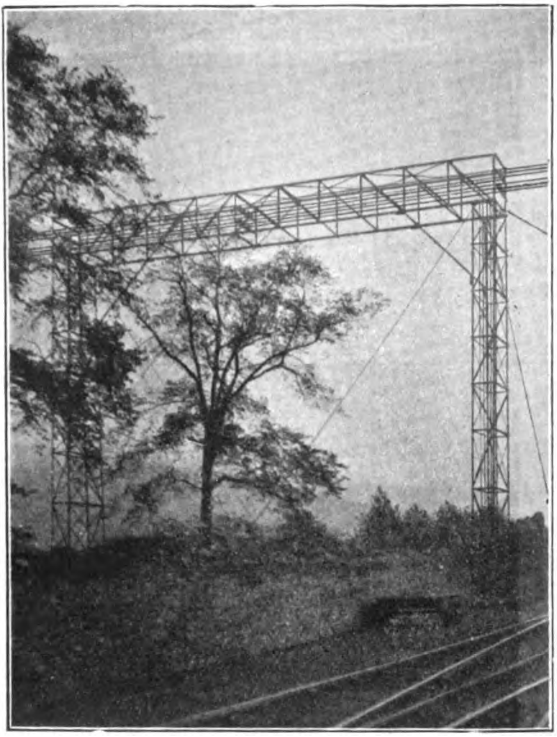
OVERHEAD TRANSMISSION. (1) HIGH-TENSION TRANSMISSION LINE ALONG RAILWAY WITH TELEPHONE BELOW. (2) CORNER STRAINING POLES.



Overhead Transmission. Constructional iron gantry carrying high-tension mains across main road and telegraph line at Aberaman.

oil break switch and enclosed fuses, the latter contained in a cast-iron gas-tight case. Access can only be obtained to the fuses of each individual panel when the switch is in the "off" position. Fuses are used at the sub-stations in place of automatics as continuous attendance is not provided at these points; each motor being protected by an automatic cut-out, a feeder fuse only blows when something is seriously at fault.

Three-phase power transformers, 500-volt secondary pressure, of 670k.v.a, are erected in these sub-stations to supply the smaller motors, together with 170kw. of single-phase lighting transformers, 110-volt secondary pressure.

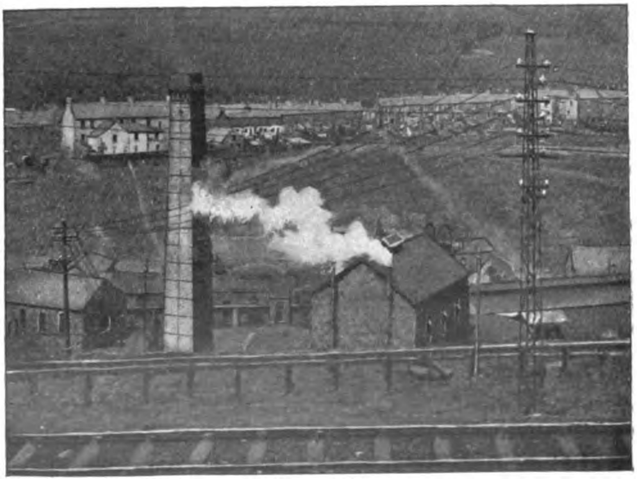
Each shaft has duplicate 3-core cables, 0.08 square inch section, insulated with impregnated paper covered with copper tape 15mils. thick, the whole lead sheathed and armoured with 50 of No. 12 S.W.G. galvanised steel wires separated from the lead.

These cables are carried in the shafts by wrought-iron cleats attached to the beyots placed from 7yd. to 10yd. apart, the cleats being bushed with hard-wood bushes; the cables are jointed in cast-iron joint-boxes, both the armouring and the copper tape being kept electrically continuous at the joints.

The 3000-volt armoured cables are carried down four of the pits, and extend a distance of 700yd. from the pit bottom. The cables are hung along the roadways, supported by leather thongs, so that in case of a fall the support will give way without putting serious strain on the cable.

The pit lighting is independent of the power cables; the original wiring (used when the pits were supplied with direct current) is now fed with alternating current from the sub-stations above ground.

Mine cables have been provided for the following pits: Aberaman of 300yd., Lower Duffryn of 348yd., Abercwmboi of 300yd., and Fforchaman of 200yd., shaft depth.



Overhead Transmission. View of Cwmneol Colliery, showing duplicate feeder tee'd off main high-tension transmission line to Fforchaman, with lattice steel tee-off pole.

The distribution from the sub-stations to the various motors above ground, both 3000 and 500-volt, consists of bare wires supported on insulators attached to wooden poles or to the existing buildings. These wires are guarded in a similar manner to the transmission wires, and are protected by lightning arresters at the sub-stations.

Where high-tension wires are supported on the existing buildings, the conductors are kept 9in. apart, for supports 6yd. apart, the conductors in all cases being kept well above the ground level.

The connections between the switch-gear and the individual motors below ground consist of 3-core armoured cable, special care being taken to see that the frame of the motor, controller, and sheathing of the connecting cable are all in electrical contact, with one another and with earth.

Above ground the same method is used for the high-pressure connections, the low-pressure connections being made by single rubber-covered wires mounted on insulators, protected by expanded metal guards where accessible.

In order to provide a good earth connection in each pit, in addition to the armouring, which has been carefully bonded, a bare copper conductor of 0.1 square inch section has been taken down each shaft, from which earth wires, having 25 per cent. greater area than the individual wires in the distributor, have been laid to each motor so as to insure a good earth connection for the motor frames, switch-gear, and controller cases.

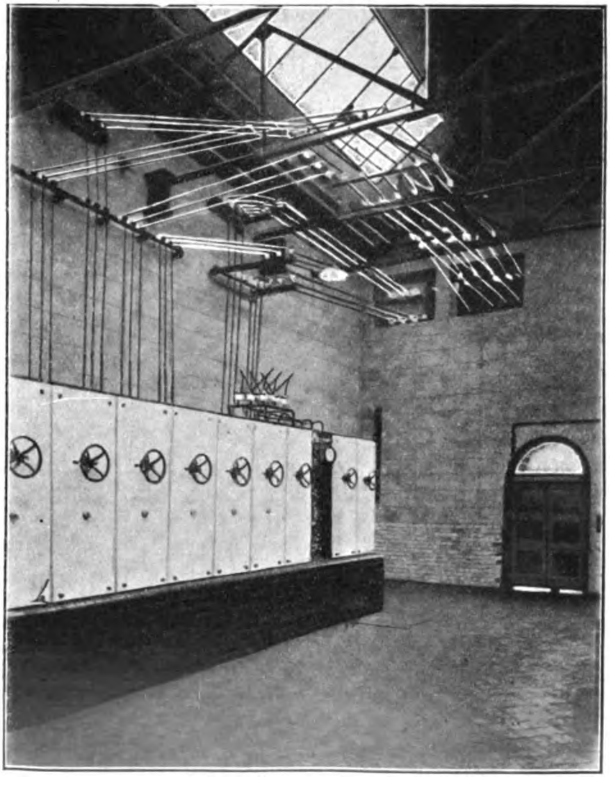
The neutral point of the star winding of the generators is earthed at the power station, and the neutral point of the 500-volt transformers is earthed at each sub-station.

Three-phase motors aggregating 4600b.h.p. were specified for in the first instance, and whilst the work of erection was in progress further motors were added, bringing the total up to date (the time of the reading of the paper) to 6000h.p.

The motors may be divided into two classes—variable speed, for haulage and winding; constant speed, for driving fans, pumps, screens, conveyors, workshops, and brickyard.

Forty motors of the first type were at work in January, 1906, varying in power from 300b.h.p. to 25b.h.p., totalling 3260b.h.p.; and 37 of the second type, from 180b.h.p. to 5b.h.p., totalling 1450b.h.p.

The table at the top of the next page gives a classification of the total power used at these pits at that time, 4710b.h.p. being electric, the balance of 7460b.h.p. being steam driven, of which a further 1000h.p. was then being converted to electric driving —total, 12,170b.h.p.



Sub-station. General view of a high-tension sub-station switchboard, showing lightning arresters and interior wiring. (Aberaman.)

In addition 170kw. of transformers are used for the lighting service above and below ground.

Twenty-six of the motors given in the table, of 3500b.h.p., are wound for 3000 volts, all motors of capacities below 50b.h.p. being wound for 500 volts.

	No. of Motors.	Electric.	Steam.	Total.
Winding	3	280	4400	4680
Haulage (above ground)	28	2400	300	4030
,, (below ground)	5	580	750	
Fans	3	380	500	880
Pumps	6	340	450	790
Screens	4	240	—	240
Washery	—	—	430	430
Air compressors	—	—	470	470
Auxiliary motors, conveyors, workshops, brickyards ..	46	490	160	650
Totals	5	4710	7460	12,170

The general method of drive is by cut-steel gear, and in order to reduce the ratio of reduction as far as possible a motor speed (at full load) of 121r.p.m. was chosen for the 300h.p., and 290r.p.m. for the 150b.h.p. haulage motors.

The motors were fitted in all cases to existing haulage gears, replacing a steam engine, arrangements being made so that the haulage could be worked with steam up to the end of the week, the electric driving commencing the following Monday by dismantling the engine and putting the motor and gear in its place.

The high-tension motors are of the protected type, those over 75b.h.p. having bearings separate from the frame; the slip rings are carried at the end of the shaft, and are enclosed when the motors are used underground.

The table below gives particulars from the tests of both types of motors.

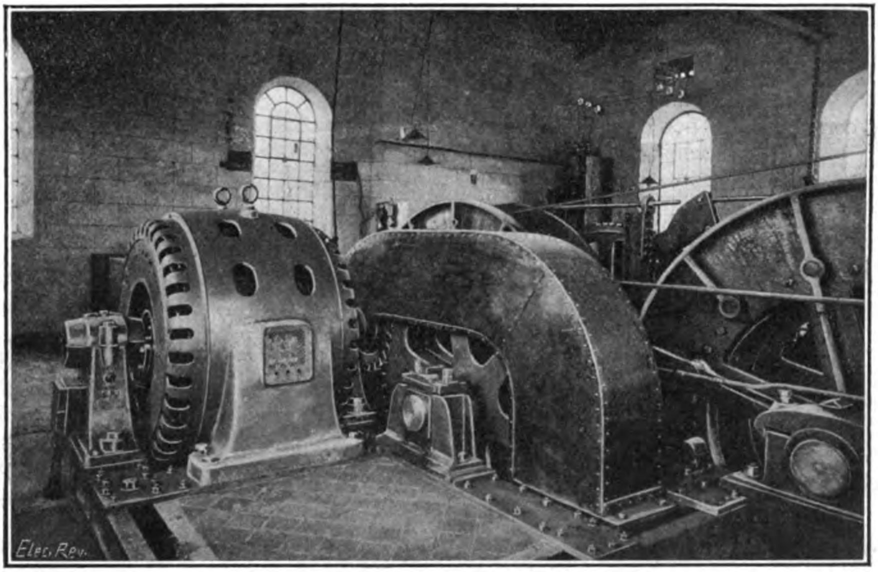
The control panels for the variable-speed motor control are erected in brick chambers with an expanded metal front, each high-tension panel having: an "isolating" switch (in the case of the motors underground, operating under oil) to allow the whole of the switch-gear, &c., for each individual motor being entirely disconnected from the system; three-phase oil switch combined with "overload" relay; and series transformer for measuring current.

Each haulage has an ammeter to act as a guide to the driver, the dial being marked to show the rated working current of the motor, and the overload point at which the circuit breaker will operate, the motor not breaking out of step unless an overload of 2½ times its working current is exceeded.

The controller and high-pressure reversing switch are combined, and are operated by one handle through gear and levers. The controller consists of a metal case in which is mounted a revolving drum on which two lines of rubbing contacts are fixed, arranged in parallel spirals; fifteen fixed contacts connected to the rotor resistance are placed vertically at each side of the drum (the whole of the contacts operate under oil when used underground). Each of these contacts carries three copper fingers, reinforced by an adjustable flat steel spring. The tips are copper wedges screwed to

	Haulage Motors. Variable Speed.			Motors for Continuous Service. Constant Speed.		
Rated b.h.p.	150	75	50	100	50	25
Volts	3000	3000	3000	3000	3000	500
Diameter of rotor	42.5"	30"	25"	42"	24"	19.25"
Speed (at full load)	290	365	365	290	485	485
Efficiency: Full	89.5	80	85	90	91	87.5
.. ..	89	88	84	91	90	88
½	87.5	86	82	91	88.5	87
Cos ϕ; Full	.78	.82	.72	.87	.83	.85
¾	.71	.78	.63	.86	.77	.80
½	.60	.68	.5	.82	.65	70
Maximum starting torque	2.55	2.7	3.3	1.8	3.6	2.5
Air-gap (inches)	.08	.06	.06	.05	.04	.04
Temperature rise	35° C.	30.5° C.	45° C.	37° C.	60° C.*	30° C.
Weight of motor in lb. without bed plate ..	6600	3600	2900	6000	3800	2150

* 70b.h.p. motor rated at 50b.h.p. totally enclosed.

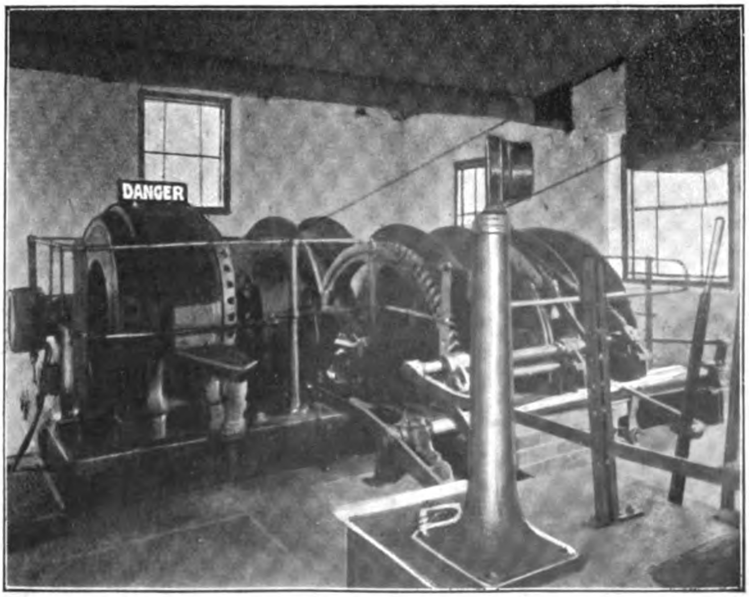


Haulage. Converted Main Haulage Machine at Aberaman Colliery, Driven by 250b.h.p. Motor at 290r.p.m. through Cut Steel Gearing.

the end of the fingers, all contacts, both stationary and revolving, being designed to be easily renewable.

The first four sets of contacts are arranged to cut out whole sections of resistance, the remaining contacts cutting out half sections, the reverse action taking place when the resistance is being put in. The high-tension reversing switch is bolted to the side of the controller. Four contacts controlling two of the three phases supplying the stator are reversed under oil by a revolving switch. In order to provide for smooth operation the controller provides for 26 motor speeds.

The resistances for the rotor circuit are cast metal grids. These are mounted in frames placed close to the controller, the frames being well ventilated and protected by expanded metal guards; the connections between the resistances and the controller are carried in an earthed iron pipe or protected by expanded metal guards.

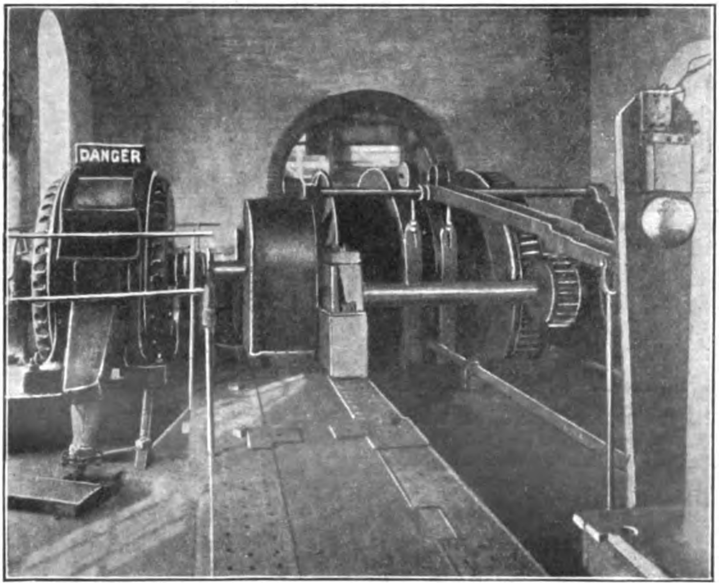


Haulage. General View of a Typical Converted Haulage Gear Driven by a 150b.h.p. Motor at 290r.p.m., Showing Driver's Platform and Instrument Column.

The characteristic curves of the 150b.h.p. haulage motor show when working from three-quarter load to 25 per cent. overload an average efficiency and power factor of 89 per cent. and 78 per cent. respectively, the slip at full load being 3 per cent. The following are representative instances of drives for haulage, fans, pumps, winding, &c.

Main and Tail Haulage.—Fourteen of these are driven by 150b.h.p., 3000-volt, 290r.p.m. variable speed motors. The leading details of the gearing and weight handled by one of these haulages, arranged with two drums in tandem, are as follows:

Diameter of drums	... 4ft. 6in.
Drum, cast-iron helical gear	84 teeth, 2½in. pitch ×9½in. wide.
Drum pinion	... 28 teeth, 2½in. pitch ×9½in. wide.
Motor cut-steel spur wheel	... 66 teeth, 2⅝in. pitch ×9⅞in. wide.
Motor pinion	... 22 teeth.
Length of rope ...	... 1450yd.
Weight of rope ...	... 2.12 tons.
Diameter	... ¾in.
Number of trams ...	... 20.
Weight of trams ...	... 20×9cwt. = 9 tons.
Number of shackles ...	... 19.
Weight of shackles ...	... 19×30lb. = .25 ton.
Weight of coal per journey	... 20×26cwt. = 26 tons.
Total weight hauled ...	... 37·3 tons.
Time occupied per journey	... 4½min.
Speed of journey ...	... 5½ miles per hour.



HAULAGE. GENERAL VIEW OF CONVERTED HAULAGE GEAR AT LLETTY SHENKIN, WITH 125B.H.P. HAULAGE MOTOR.

The energy required averages one unit per ton of coal hauled, the following list giving representative instances:

Length of road in yards	1100 ...	1320
Gradient, inches per yard ...	1 to 4½...	1 to 4
Time per journey, minutes ...	7½...	9
Coal per journey, in tons	27 ...	27
Completed journeys per day ...	17 ...	19
Coal hauled per day	460 ...	520
Units per day	425 ...	490
Units per ton of coal hauled ...	.92 ...	.94
Maximum kw. input into motor ...	286 ...	242
Load factor of haulage (250 working days)	4.25% ...	5.8%

These low load factors are due not only to the intermittent working of the journeys, but to the power required at starting and on mounting a gradient.

Before conversion, when the haulages were steam driven, the engines slowed down at each heavy gradient, but now the haulage is electric three-phase the speed is maintained whatever the gradient, and, in consequence, the power taken momentarily is great. The large power taken by "main and tail" haulage shows the great advantage of the continuous haulage system where roadways will allow this method of operation.

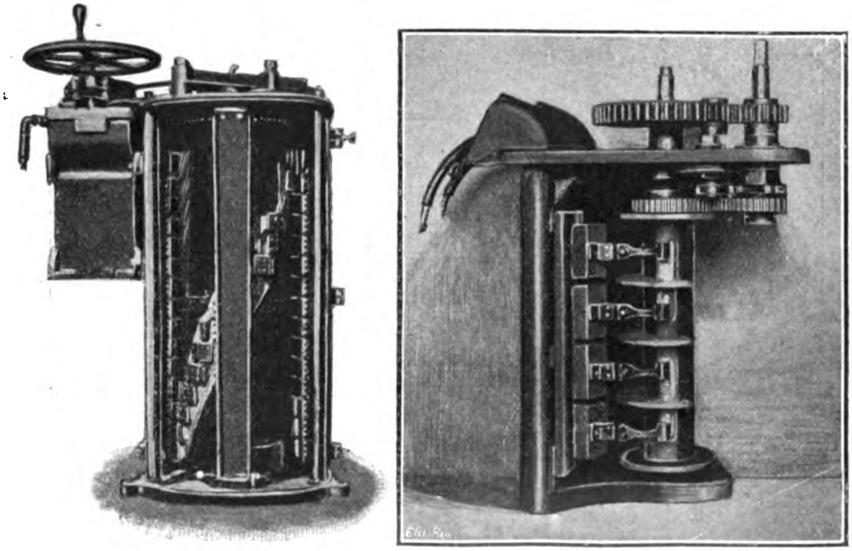
The general details of one of the underground haulages, which has been converted from steam, having drum speed 32r.p.m., equivalent to five miles per hour, are: drum cast-iron double helical gear: teeth 84, pitch 3½in., width 9½in., pinion teeth 28. Motor spur wheel, cut steel: teeth 66, pitch 2⅝in., width 8⅝in.; motor pinion, cut steel: teeth 22. The operator faces the motor, having the clutches on his left, brake levers and ammeter in front of him, and the controller on his right.

Fans.—180b.h.p. 3000-volt motor, protected type, running at 290r.p.m., fan being rope driven at 175r.p.m. Air delivered by fan, 150,000 cubic feet per minute with 3¾in. water gauge. The air pressure secured by this method of drive is more uniform than is usually obtained with steam-driven fans. The switch-gear used is of the same type as that employed for the haulage motors with the exception that the starter is a liquid resistance. The fan motors are run at full load continuously, being shut down for examination and cleaning for ten minutes every three weeks.

Screens.—60b.h.p., 3000-volt enclosed motor, 485r.p.m., the screens being rope driven. Switch-gear as above. Liquid starter employed.

Aerial Rope Ways.—15b.h.p., 500-volt motor, 575r.p.m., belt driven. Liquid starter.

Pumps.—100b.h.p., 3000-volt motor, 485 r.p.m. Three-throw Uskside ram pump, rope driven, 9in. cylinders, 15in. stroke, 22r.p.m., delivering 13,000 gallons per hour against a head of 1020ft.



(1) CONTROLLER FOR HAULAGE MOTOR. (2)
(1) GENERAL VIEW, WITH ROTOR DRUM UNCOVERED. (2) DETAIL VIEW OF HIGH-TENSION STATOR REVERSING SWITCH.

40b.h.p., 500-volt enclosed motor, 720r.p.m., driving centrifugal pump direct against head of 100ft.

Winding.—100h.p., 3000-volt motor, r.p.m. (full load) 290. Depth of pit, 90yd. Time occupied in wind, 40 seconds. The cage holds one tram. Output, 70 tons of coal per hour. As the workings are being opened out only 200-300 tons per day are being dealt with, out of the daily capacity of 600-700 tons.

A similar winder is used for men only. Depth of pit, 270yd.

An underground winder is in use at Fforchaman in a staple pit. Depth, 100yd. The winder is driven by 80h.p. motor, 360r.p.m. (full load), 3000 volts, working a single cage holding one tram, the load being balanced by a weight. The time occupied is 50 seconds. The maximum speed of the rope is 486ft. per minute. Output at the rate of 30 tons per hour.

Load Factor on Power Station.—With motors of 1366b.h.p. connected, a daily output of 4400 units, and maximum demand of 800kw., the load factor is 22.5 per cent.

With motors of 3900b.h.p. connected, a daily output of 14,900 units, and maximum load of 1200kw., the load factor is 51 per cent.

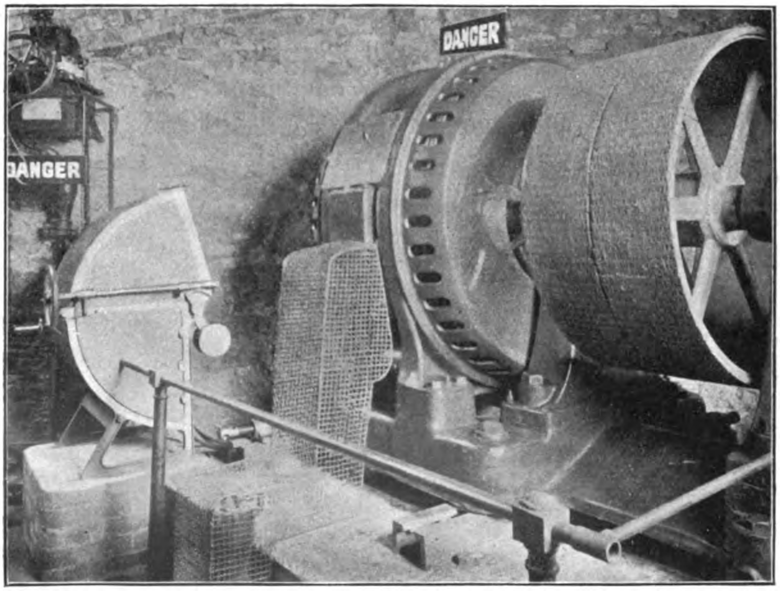
The annual load factor is lower than the above figures, as the power station only supplies for ventilating, pumping, and a small amount of lighting on 1½ days of each week ; in addition, stop days and holidays have to be allowed for.

Tests on individual "main and tail" haulages working 17-20 journeys per day give load factors (based on 250 working days) of 4¼ to 6½ per cent.

Ventilating fans give a load factor of nearly 100 per cent.

With pumping, the load factor depends on position and quantity of water, the best load factor being obtained when storage allows the pumping to be confined to the night shift, the pumps only being run when the haulages are not in use. By this means no extra capacity in generating plant is required for driving the pumps. Screens and conveyors have a load factor of 30 per cent.

Workshops and auxiliary motors taken collectively have a load factor of 33 per cent. (load factor for individual motors being one quarter of this figure).



180B.H.P. MOTOR BELT DRIVING VENTILATING FAN AT OLD DUFFRYN, WITH LIQUID STARTER.

The maximum sustained load on the power station reached during the last quarter has been 1400kw.; the output being at the rate of 4,500,000 units per annum; this gives a load factor of 37 per cent., and if a year is taken without addition of further motors the load factor with the present methods of working would lie between 35 and 40 per cent.

This high load factor is obtained by supply to seven pits, and results from the combined supply of a number of drives, many of which have exceedingly low load factors.

These figures indicate the difficulty a small colliery has in converting from steam to electric driving, as the capital charges due to the low load factor, extra cost of reserve plant, and greater cost per kw. for small units, will result, even with cheap fuel, in much higher costs than those given in this paper; and it is works of this description that offer the best opportunity to power companies, as it is only in cases where a considerable proportion of the power is required for pumping that an isolated pit requiring main-and-tail haulage could obtain a sufficiently high load factor to give low working costs when generating with its own plant.

COSTS.

Power Station.—Buildings, steam plant, generators, and switch-board per kw. of plant erected (normal rating) ... ...£11 10s. per kw.

The cost of the equipment per b.h.p. outside station, transmission and distribution (overhead and underground) substations, transformers, and switchgear ... ... £2 12s.

Motors, controllers, switchgear, and gearing, per b.h.p. ... ... £3 18s.—£6 10s. per b.h.p.

The cost per unit delivered to the colliery transmission lines, with an output of 4½ million units per annum, load factor of 37 per cent., using unwashed small coal (calorific value 13,000b.t.u.) costing 4s. 2d. per ton:—

Works costs	0.18d.
Interest and depreciation 10 per cent. on power station ...	0.185d.
Total	0.365d.

The reserve plant in the power station at present is 100 per cent.; this will fall to 66 per cent. when the power station is completed by the addition of a further 1500kw. unit, and the cost will be reduced to under 0.3d. per unit delivered to the colliery mains at a load factor of 45 per cent.

The whole of this contract was carried out by The Electrical Company, Ltd., under the supervision of Mr. A. E. Hadley, with Mr. F. J. Rynd as resident engineer.

• [We are advised by Mr. Sparks that the above description of the Aberdare Valley equipment of the Powell Duffryn Company is still substantially correct, but that the number of haulage motors has been increased, including one of 300h.p. at 122 r.p.m. The overhead network has been extended to the George Colliery, which is equipped in a similar manner to the others. A centrifugal pump of 450h.p. has been added to the Middle Duffryn Colliery, this pump being run during the night when the haulages are stopped. It is of further interest to note that during last year the output of the generating station amounted to 4,800,000 units.—*Editor Elec. Mag.*]

The Electric Power Equipment of the Tarbrax Oil Co., Ltd.

JAMES CALDWELL.

[During June, 1906, the members of the Mining Institute of Scotland visited the oil works of the Tarbrax Company. As will be gathered from the following abstract, the paper read by Mr. Caldwell on that occasion, the electrical equipment is of exceptional interest to colliery men, although it deals with a shale mine.]

The plant at the power station consists of two Westinghouse three-phase generators, each of 300kw., supplying current at a pressure of 440 volts and 50 cycles, coupled direct to two Belliss & Morcom three-tank compound steam engines of 450b.h.p., the steam being supplied at a pressure of 150lb. per square inch from three Stirling water-tube boilers.

The electric winding-gear, the first of its kind in Great Britain, was designed and erected by Messrs. Bruce Peebles & Co., Ltd. The plant is upon the Ilgner principle, which has been largely adopted on the Continent with considerable success. The power for this gear is supplied by three-phase overhead mains across the moor from the power-station at the works. The pressure of the supply is 420 volts, at which the current is taken to the stator of the induction motor of a flywheel motor-generator. The flywheel motor-generator consists of an induction-motor, a continuous-current generator, and a heavy flywheel, all mounted on the same shaft. The merit of the Ilgner system of winding is due to the use of a heavy flywheel. Its chief function is the storing of energy, and it thus compensates the variations in energy required by the winding-gear itself. The capacity of the three-phase induction motor driving the flywheel motor-generator is 80b h.p., running at a speed of 730r.p.m. The generator of the motor generator is a continuous-current machine, with compensating poles, and is of equal capacity to that of the induction-motor; but it is specially designed to withstand extreme heavy overloads, working up to 400h.p. for short periods, this being about the peak of the winding load. The field of this machine is separately excited with a voltage capable of being varied from zero.

To accelerate the winding motor, the resistance is cut out of the field circuit of the generator, thus increasing the strength of the field, and thereby the voltage of the current is supplied to the winding-motor armature. Conversely, an electrical brake is applied to the winding gear by weakening the generator field, so that the winding-motor becomes a generator, and the generator of the motor-generator becomes a motor, and accelerates the flywheel, thus storing up energy for the next wind.

The flywheel is 6½ft. in diameter, and weighs 6 tons. It is a special Krupp-steel casting, turned and balanced complete, having a flywheel effect of 6,700,000 foot-pounds, with a good safety factor. It runs at a speed of about 730r.p.m., and is supported by special water-cooled bearings with forced lubrication.

The winding motor is of the continuous-current shunt-wound open type, directly coupled to the winding drums. It is constantly excited by a small three-phase induction motor of 10b.h.p. direct-coupled to a continuous-current generator, the speed of winding being varied by varying the excitation of the generator, thus raising or lowering the voltage of supply to the armature of the winding-motor. The horse-power of this motor is 200 and the speed 57r.p.m. It is started by a controller worked by a lever, which regulates the excitation currents, and completely controls the winding-motor, thereby enabling the winding to be performed at various speeds.

A three phase star-connected motor automatically inserts resistance in the rotor of the main three-phase-induction-motor, the windings of which are in series with those of the small three-phase star-connected motor. The rotor of this star-connected motor is not allowed to run, but simply "torques," being prevented from running by a balance-weight. When the current flowing from the winding exceeds 60amp. per phase, the motor is able to lift the balance-weight and rotate the brushes upon a commutator-type controller, thus automatically inserting resistance in the rotor; the amount inserted being in proportion to the stator-current.

There is also an additional rheostat of the liquid type provided for running the flywheel motor-generator up to speed. When this is in circuit, the small regulating motor is cut out by a change-over switch. It may be mentioned that it takes some 20 minutes to run the flywheel up to its speed, and that several complete winds can be performed by the inertia of the flywheel alone.

The two winding-drums are each 8ft. in diameter and 2ft. wide. The brakes are of the double-breasted post type, consisting of steel uprights of H section, 8in. by 6in., having saugh brake-locks, one brake being actuated by hand and the other by compressed air, the latter being regarded as an emergency brake to prevent over-winding. The air-brake comes automatically into operation should the cage have a tendency to come above the landing-stage, the depth-indicator (of the travelling pointer and scale type) opening a valve which instantly applies the brake. The winding ropes are 1$\frac{1}{16}$in. in diameter.

The plant is designed for an output of 640 tons in 8 hours from a depth of 420ft. The full load is 25cwt. per wind. The whole journey is completed in 25 seconds, the speed being 23ft. per second, and the time allowed for decking is 30 seconds per trip.

In equipping the No. 1 Pit, and in order to cope with the heavy water, the choice, after full consideration, fell upon the Oddie-Barclay pump, because it runs at a moderate speed, and seems to mark an advance in high-speed pumps, since there are fewer working parts than in some of the other well-known types.

The main pump is situated in a chamber near to the pit-bottom, and delivers about 380 gallons per minute against a head of about 450ft., including friction. It has two rams, 8½in. diameter by 12in. stroke, the speed is about 80r.p.m., but it is designed to run at 130 revolutions and about 600 gallons per minute. It is electrically driven by means of a belt, the power being obtained from an induction-motor. The motor is of 100h.p. and is supplied with current from a sub-station on the surface at a pressure of 420 volts. The pump is of the high-speed single-acting type. All the working parts of this pump are easily accessible for inspection. The cranks are placed at right angles.

The features of this and all the Oddie-Barclay pumps, as made by the sole makers, Messrs. Andrew Barclay, Sons & Co., Ltd., Kilmarnock, is the valve-controlling arrangement fitted to the suction-valve. It is this, together with the special design, ample bearing surfaces, and good workmanship, which admits of running such pumps at a high speed without causing shock or banging of the valves on their seats.

The ventilation of the workings of the No. 1 Pit is carried out by means of a Capell single-inlet close fan, made by Barclay's Kilmarnock; it is 10ft. in diameter by 4ft. 3in. wide, and is capable of delivering 100,000 cubic feet of air per minute at 3in. of water-gauge, when running at about 220 r.p.m. This fan is belt-driven by an electric motor of 30h.p.

Electric Power Installation at the Bradford Colliery, near Manchester.

There are few cases where electrical transmission can be more profitably applied than in that of transmission of power to mines. Electric power plants for colliery work, however, have not been taken up in this country as extensively as might reasonably have been expected. The many advantages of electricity over steam, air, and other powers for this class of work must be apparent to most colliery engineers and managers; but, although it is the ideal means of taking power into the workings, it has, up to the present, been mainly confined to lighting at bank, pit bottoms, engine rooms, heapsteads, &c. This is probably due to the difficulties of running and maintaining cables through the falling of roofs and other risks, and to the supposed danger from sparking at the motors. There is, however, no difficulty in avoiding or overcoming these troubles if the scheme is carefully considered in its initial stages. This has been prominently demonstrated in the power installation put down at the Bradford Colliery Company's works, near Manchester, by Messrs. J. H. Holmes & Co., of Newcastle-on-Tyne.

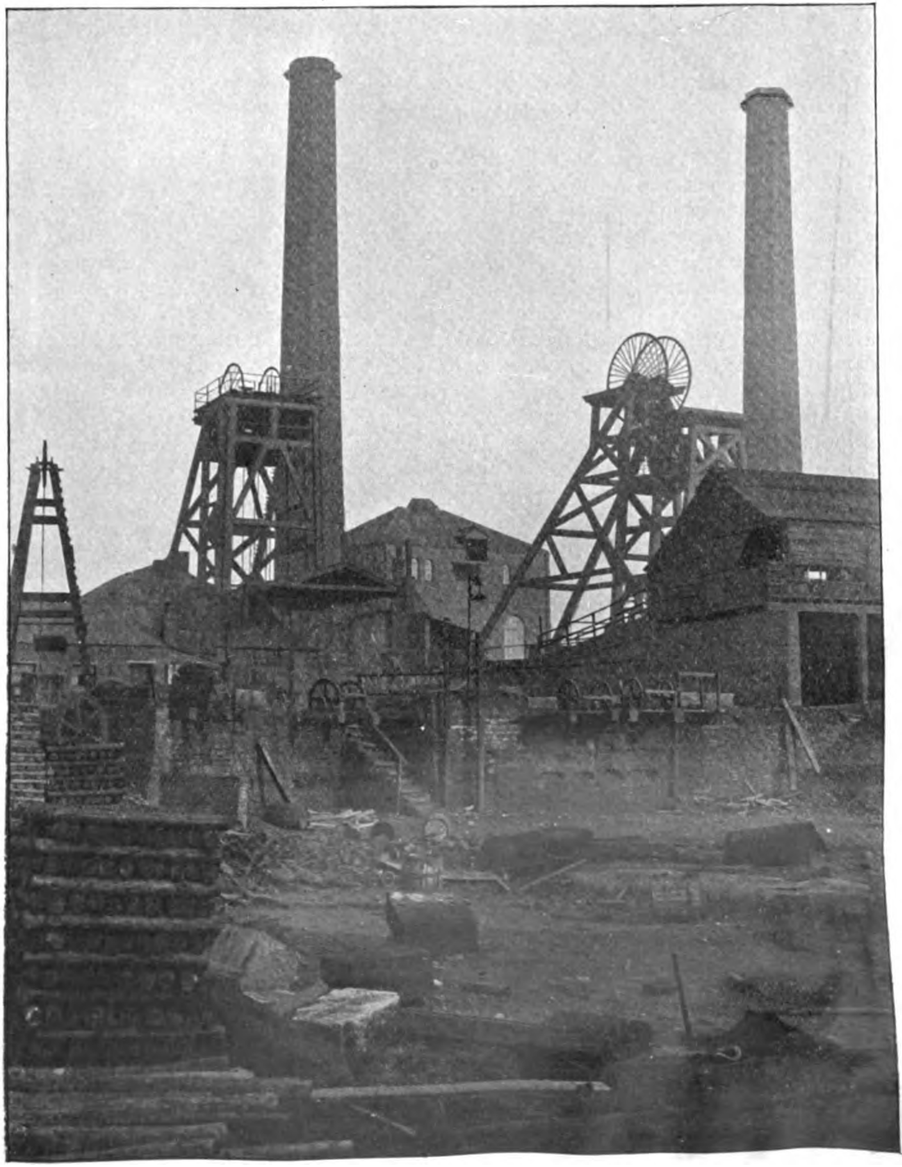


FIG. I. GENERAL VIEW OF THE BRADFORD COLLIERY, NEAR MANCHESTER. ELECTRICAL EQUIPMENT BY MESSRS. J. H. HOLMES & CO., NEWCASTLE-ON-TYNE.

In the power house, there are four coupled steam generators, three of which are used for power, and the fourth for surface lighting. The engine sets, together with the motor generator, are mounted on combination bedplates. Three engines are of Messrs. Browett, Lindley & Co.'s self-lubricating enclosed compound vertical type, the fourth being of that firm's open type.

Two of the engines, which have cylinders 14½in. and 24in. by 10in. stroke, are each capable of developing 195b.h.p. with 90lb. steam pressure, and of sustaining an overload of 25 per cent. for two or three hours when required. They are fitted with special shaft governors and heavy flywheels, and are coupled direct to two Johnson-Lundell six-pole traction generators designed for an output of 130kw. each at 525 volts, at 380r.p.m., and for a 25 per cent. overload for two or three hours, with fixity of brushes and sparkless commutation.

These generators are fitted with split laminated pole pieces, having an extended pole tip on one side, so proportioned that this half of the magnet core is saturated by the shunt turns alone; as the load increases, the compound winding quickly changes the induction density in the other half of the pole, at which point a strong field is required to obtain sparkless commutation at all loads. With cores of this description, it has been proved possible to employ a much smaller air gap and to deal with greater armature reactions. It has been found possible in practice to run these generators for short periods at 100 per cent. overload without altering the brush lead or causing destructive sparking.

The armatures are slot-wound, and the commutators are of ample diameter, composed of hard-drawn copper with mica insulation, of such dimensions as to ensure adequate capacity to carry the maximum current without excessive heating. The brush-holders are carried from substantial split rings, with adjusting screw attached to the yoke ring. The bearings are self-adjusting and self-oiling.

The largest dynamo absorbs 500b.h.p. and gives out 340kw. with a voltage of 525 at 250r.p.m. The engine to which this is directly coupled is totally enclosed, with forced lubrication, and has three cylinders, one h.p. 24in. diameter, and two l.p. 27in. diameter, with 12in. stroke; at 90lb. pressure, it runs as a compound engine.

The generator has eight poles of the Johnson-Lundell split-pole type, as previously described. The armature is 52in. diameter and 11¼in. long, with a thoroughly well ventilated core, so that the temperature rise on the six hours' test was only 40deg. Fahr.

The surface-lighting plant consists of a motor generator and a "Castle" two-pole dynamo with drum armature wound with laminated conductors. This latter has an output of 15kw. at 230 volts, 225 revolutions, and is coupled to an open engine having a single cylinder 9½in. diameter and 9in. stroke, with automatic expansion governor working at 90lb. steam pressure.

The motor generator is used to transform the high volts used for power down to the 230 volts necessary for the lamps used on the surface. The motor absorbs 70b.h.p. at 525 volts, driving the generator, which has an output of 47kw. at 230 volts, the combination running at 500 revolutions. Both machines are of the "Castle" six-pole type, are of the same size, and designed for running continuously with a low temperature rise. The motor is shunt-wound and of the totally enclosed type and the generator compound-wound.

The main switchboard in the engine house is very complete, and is composed of enamelled slate panels with separators between the positive and negative poles. The main generator panels are fitted with dead-beat ammeters, automatic circuit breakers, patent quick-break chopper switches, and the necessary fuses. Dead-beat voltmeters are fitted at the top of the board together with a clock, these being mounted in an ornamental pediment. The dynamo shunt regulating switches and resistances are of Messrs. Holmes' well-known switchboard type, these being so arranged that the resistance coils are coupled direct to the switch contacts at the back of the panels, so that no connecting wires are necessary for joining up the switches to the resistances. The circuit panels are fitted with double-pole chopper switches and fuses, there being a dead-beat ammeter provided for each circuit. The whole board is mounted in a moulded frame, the total length of the board being over 20ft.

The switchboards fitted near the various motors are each provided with an ammeter and an automatic circuit-breaker to ensure the current being cut off should there be

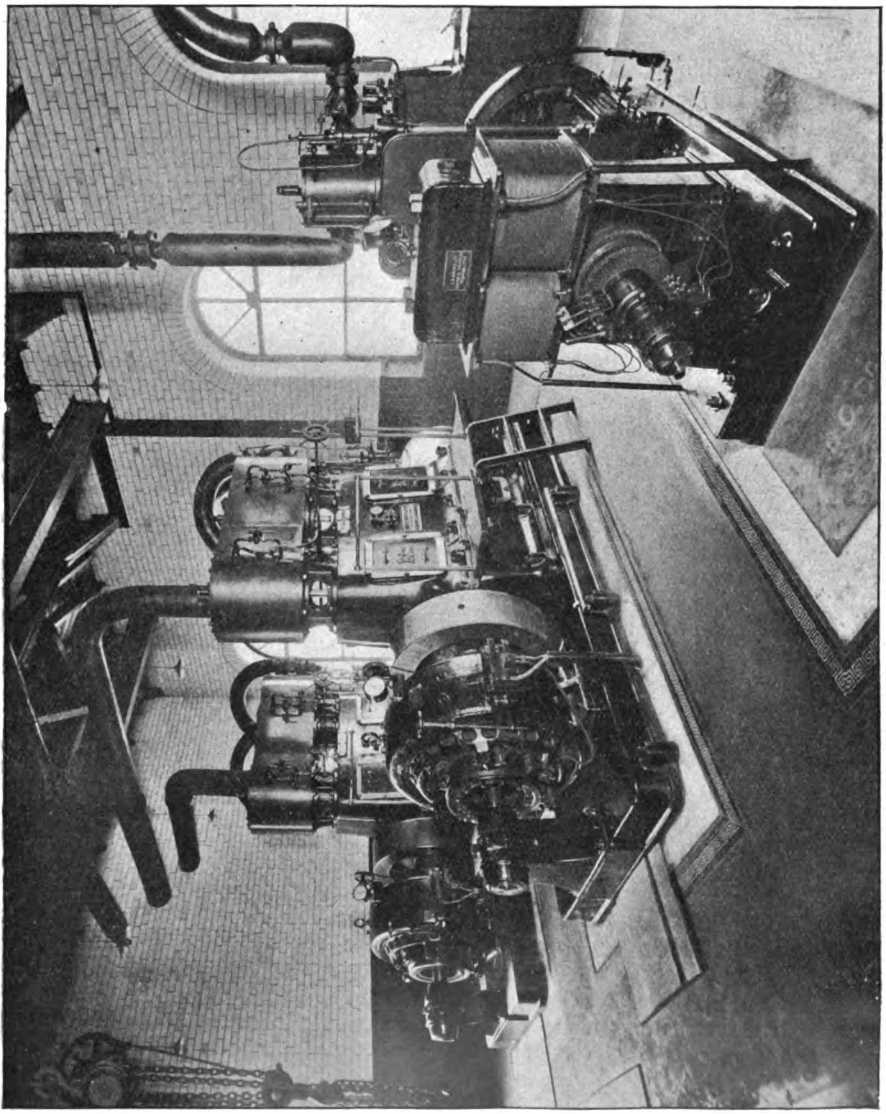


FIG. 2. INTERIOR OF ENGINE HOUSE, SHOWING A PORTION OF THE ELECTRIC GENERATING PLANT. THE BRADFORD COLLIERY COMPANY, LTD.

any accidental short circuit at the motor or an occasional overload. In practical working these circuit-breakers are found extremely useful, as they give the men a good idea as to what load they can put upon the motors. As a general rule they save the fuses blowing, and it is a much more simple matter to close the circuit-breaker than to replace a fuse. These boards are also provided with the usual chopper switches and fuses, and are encased in strong covers with heavy plate-glass fronts.

The cables are of the Telegraph Manufacturing Company's (now British Insulated & Helsby Cables, Ltd.) make, the largest used for conveying current underground, being 61 by .090. All the cables are armoured and lead covered, of the 2500 megohms quality. The cables at the pit bottom are so arranged that in the event of one pair of cables breaking down they would be cut out and the supply taken from one of three sets until the repairs were made good, thus obviating the risk of a stoppage to any part of the workings.

There are four hauling sets, three for endless rope and one for tail rope. Each of the endless rope sets is driven by a 65b.h.p. enclosed "Castle" six-pole motor, compound-wound, and designed to run at 300 revolutions per minute on a 500-volt circuit. The armatures are slot-wound, with formed coils, so arranged as to obtain the maximum mechanical strength, combined with the highest electrical efficiency. The motors are fixed to separate bedplates, each having three bearings of ample surface, fitted with ring lubrication and oil gauges. Grooved pulleys, 20in. in diameter, are fitted to take twelve ¾in. cotton ropes.

The hauling gear constructed for endless rope haulage is mounted on an H section frame, fitted with angle and knee pieces at the corners, in convenient lengths for taking underground and fitting up, and consists of first motion shaft driving the winding drum through double helical gearing. The first motion shaft is fitted with a 6ft. 8in. diameter split pulley for twelve ¾in. ropes, and runs at 110r.p.m.; from this, the power is transmitted by double helical gear to the winding drum. The latter is 4ft. 9in. in diameter by 8in. face, runs at 16.5r.p.m., and is fitted with cast-iron concave laggings, which are made detachable; these can be quickly removed and renewed on showing any signs of wear. Attached to the side of the drum is the brake sheave, 5ft. in diameter by 7in. face; the strap is of steel, fitted with oak blocks. The brake is applied or released by a slow motion screw fixed to the lever arm. The hand-wheel on the screw is fixed near the starting switch, thus enabling the man in charge to start or stop with promptitude.

One of the hauling sets has two drums operated by clutches, working two brows terminating at one point at the top of the brows.

One of the endless-rope gears has an extended bedplate on which is temporarily fixed a tail-rope drum 3in. diameter, and driven by an Ewart's chain from the first motion or rope-driven shaft. This was used for driving a new brow downhill, during which work the endless-rope drum was put out of gear. The new brow is just completed, the tail-rope drum put out of gear, and the endless rope put to work.

The endless hauling ropes are 2400, 1100, 1000 and 700yd. long, and can be varied to travel at from one and a half to three miles per hour. To run each rope light takes 22 per cent. of the normal full load.

These sets have been running for over five years, during which time they have been worked to their maximum capacity practically day and night without breakdown or stoppage.

The starting switches are of Messrs. J. H. Holmes & Co.'s own make, specially designed to give slow and steady starting, and to permit of running from half to full speed. Each starting switch has two slates. On the short upper slate is fixed a single-pole switch, mechanically closed on the first turn of the slow-motion screw, and afterwards magnetically held on. On stopping or failure of supply, this switch opens, and prevents any damage arising from careless handling by starting the motor with all resistance cut out. To close the switch, all the resistance must be run in, and the operation repeated. On the lower slate are fitted the bus bar and the resistance section contacts. On the slow-motion screw a crosshead is carried, to which are fixed two sliding connectors or contacts connecting the bus bar with the resistance sections.

The tail rope hauling set is similar to the larger set, except as regards the drum, which is designed to hold about 1500yd. of ⅝in. diameter steel rope, and is driven by a 20b.h.p. enclosed "Castle" six-pole motor with rope pulleys, &c., as previously described.

There are two sets of electrically-driven pumps. The high-duty pump is one of Messrs. J. Evans & Sons' horizontal treble-ram type, with rams 6in. diameter by 9in. stroke, and when running at 40r.p.m. deliver 5500gals. per hour against a vertical head of 1680ft. The motor is of the enclosed "Castle" six-pole type, capable of developing 75b.h.p. at 350r.p.m. at 500 volts. The power is transmitted through two reductions, the first being twelve ¾in. ropes, as in the haulage, and the second double helical gear. Owing to the liability which existed of this motor being flooded, it was raised to a higher level, and ropes were substituted for the original spur gearing first reduction. Starting and regulating switches and circuit-breakers are fixed close to the motor. The pumps are started up against the full column of water, as the latter is very rarely run off.

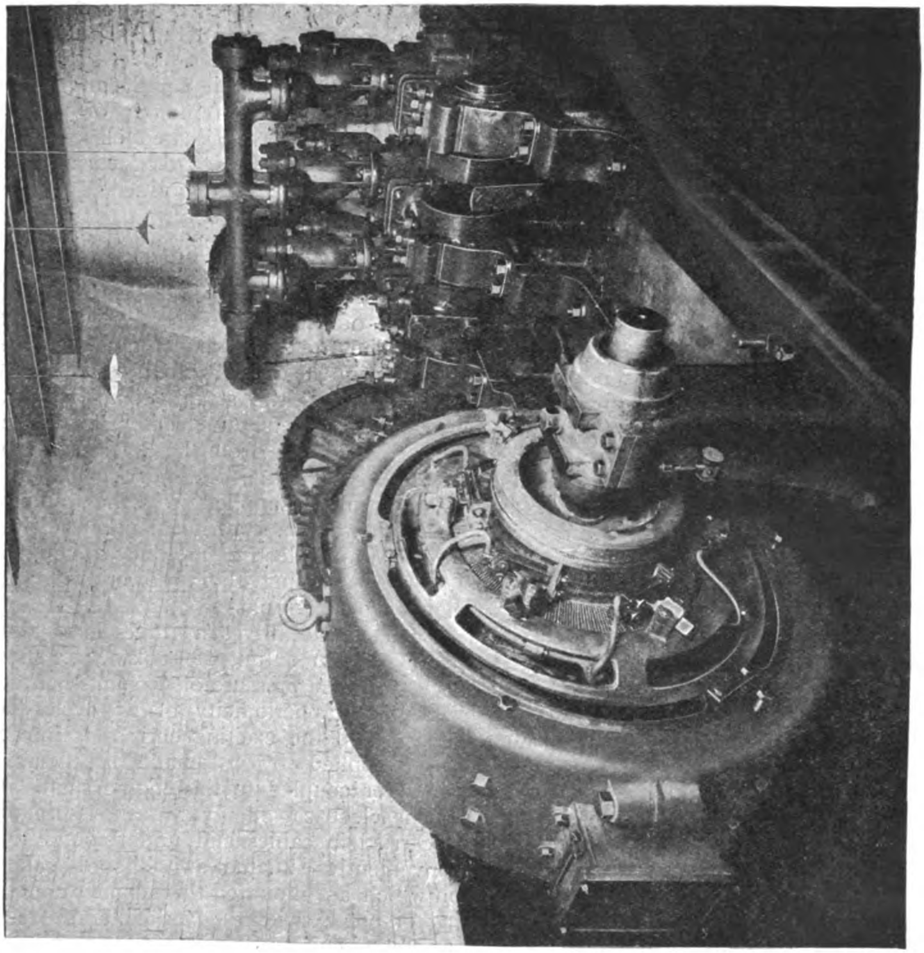


Fig. 3. Electric Pump; 5500 Gallons per Hour against 1680 feet Head. The Bradford Colliery Company, Ltd.

The low duty pump was also supplied by the above firm, and is of the same type, but fitted with rams 8in. by 9in. stroke, and at 44r.p.m., it delivers 12,000gals. per hour against a head of 470ft. This pump is driven by a 65b.h.p. enclosed "Castle" six-pole motor, running at 300r.p.m. at 500 volts, complete with gearing similar to the above, excepting that the motor is mounted on an extended bed plate, the first reduction being machine-cut steel spur and pinion wheels.

All the larger haulage and pump motors are duplicates and interchangeable, necessitating a minimum of spare parts being kept for emergencies.

The workshop tools, including circular saw, planing, morticing, and other woodworking machines, are driven by a 15h.p. "Castle" motor running at 600r.p.m.

A 10h.p. motor of the same type drives creepers underground for conveying loaded wagons from one level to another, and a second motor of this size ran for three and a half years driving a "Sirocco" blowing fan, ventilating a large shaft during the progress of sinking to the great depth of 2804ft. During the whole of this time, the motor was started at six o'clock each Sunday night and ran continuously until the following Saturday night at six o'clock. No trouble of any description or stoppage, beyond that mentioned, occurred to the motor throughout this period. It is now driving creepers on the surface for elevating wagons to a higher level.

Two motors, each of 30b.h.p., are driving mechanical screens, picking belts, slack elevators, &c.

A small but at the same time an important item in the installation is a portable air compressor, driven by one of Messrs. Holmes & Co.'s "Lundell" patent motors for cleaning the dynamos and motors.

It is interesting to place on record that the generating house has on two occasions been accidentally filled for a considerable time with steam at week-ends, everything inside being then soaked with moisture and water. No difficulty or trouble, however, has arisen in any way with the electrical plant in consequence of these accidents. Another feature which claims reference is that none of the commutators have required turning up, or any of the armatures re-winding. The record of work and continuous running such as that shown by the history of this installation is one which reflects the highest credit not only upon Messrs. Holmes & Co. as manufacturers of the plant and contractors for the installation, but also upon the management of the colliery and the efficiency of their staff.

The Mountain Ash Collieries of Nixon's Navigation Colliery Company, Glamorganshire.

Messrs. Crompton & Co., Ltd., the well-known electrical engineers and contractors of Chelmsford and London, have for many years been engaged in supplying electrical machinery for use in collieries. Some hundreds of their machines are at the present time running as dynamos generating electricity, and as motors giving out useful work in various collieries in this country. Their experience, therefore, has been most extensive, and a reference to some of their more recent contracts will be of interest and value. Amongst their later colliery equipments might be mentioned that carried out for Nixon's Navigation Colliery Company, at their Mountain Ash Collieries, Glamorganshire.

This pit is in the heart of the South Wales coalfield, where a great development of electrical power work has taken place recently; in some cases the power is derived from private installations, in others the electrical energy is purchased in bulk from the South Wales Power Company. In this particular instance the directors of the colliery company decided that it would be best to put down their own current-generating plant, and be independent of any outside public electric-supply authority. The contract for the equipment was placed with Messrs. Crompton & Co., through the agency of Mr. George Beith, of Pontypridd.

The complete installation consists of a power-generating station, surface and underground mains, and a number of motors. The engine house is situated close to the pit-head, the shaft is 370yd. deep, and the motors are in various positions grouped round the foot of the shaft.

An illustration of the power house is shown in Fig. 1. It contains three steam alternators, the engines being by Messrs. Bellis & Morcom, of Birmingham, of their usual pattern. They are two-crank compound engines working with steam at 150lb. pressure, superheated 150deg., the steam exhausting into ejector condensers, the water for which purpose is drawn from an overhead tank containing a reserve of 40,000 gallons.

This tank is supplied from the adjoining river by two 5in. centrifugal pumps driven by 23b.h.p. electric motors running at 1450r.p.m., taking their power from the main electric supply.

Each engine drives a three-phase alternator with an output of 300kw., at a speed of 375r p.m., a pressure of 550 volts between wires, and a periodicity of 25 cycles per second, and the exciting current is in each case supplied by a small direct-current generator coupled to the engine shaft.

The electrical energy from the alternators is carried in cables laid underground to a conveniently situated switchboard gallery, on which are mounted three panels containing oil-break switches, overload and reverse-current circuit breakers, ammeters and voltmeters, fuses and exciter regulators, and a complete set of synchronising gear; also four trunk feeder panels containing switches and fuses for the feeders, and the usual earth leakage indicators.

From the engine house four trunk mains are laid underground, the cables being Messrs. Callender's .25 square inch three-core conductors, insulated with vulcanized bitumen and fibre, and double tape armoured, supported in the trench.

Dividing boxes are provided at the head of the shaft, and eight cables taken down the shaft, each being a three-core cable .125 section, insulated with fibre and vulcanized bitumen, double wire armoured and supported in cleats with long glands at intervals of every 40yd. in the shaft.

Near the foot of the shaft is a distributing board, which has been erected in an old pump room, and is enclosed in a locked case. The board carries distributing fuses for eight circuits, a separate circuit being run from this point to each motor. The cables from the distributing board to the motors are of the same class as those in the shaft.

The motors are used for driving haulage gears and for pumping. There are three motors, each of 250h.p., operating main-and-tail gears for the principal roads of the pit. These motors are of Messrs. Crompton's standard three-phase type, having wound rotors and fitted with outside totally-enclosed slip rings. They are direct-coupled to the gears through the usual spur reductions, and are started, regulated, and reversed by means of large controllers working in an oil bath. The whole of this haulage plant is designed to deal with very heavy overloads, so that in the event of a fall or accident of any sort on

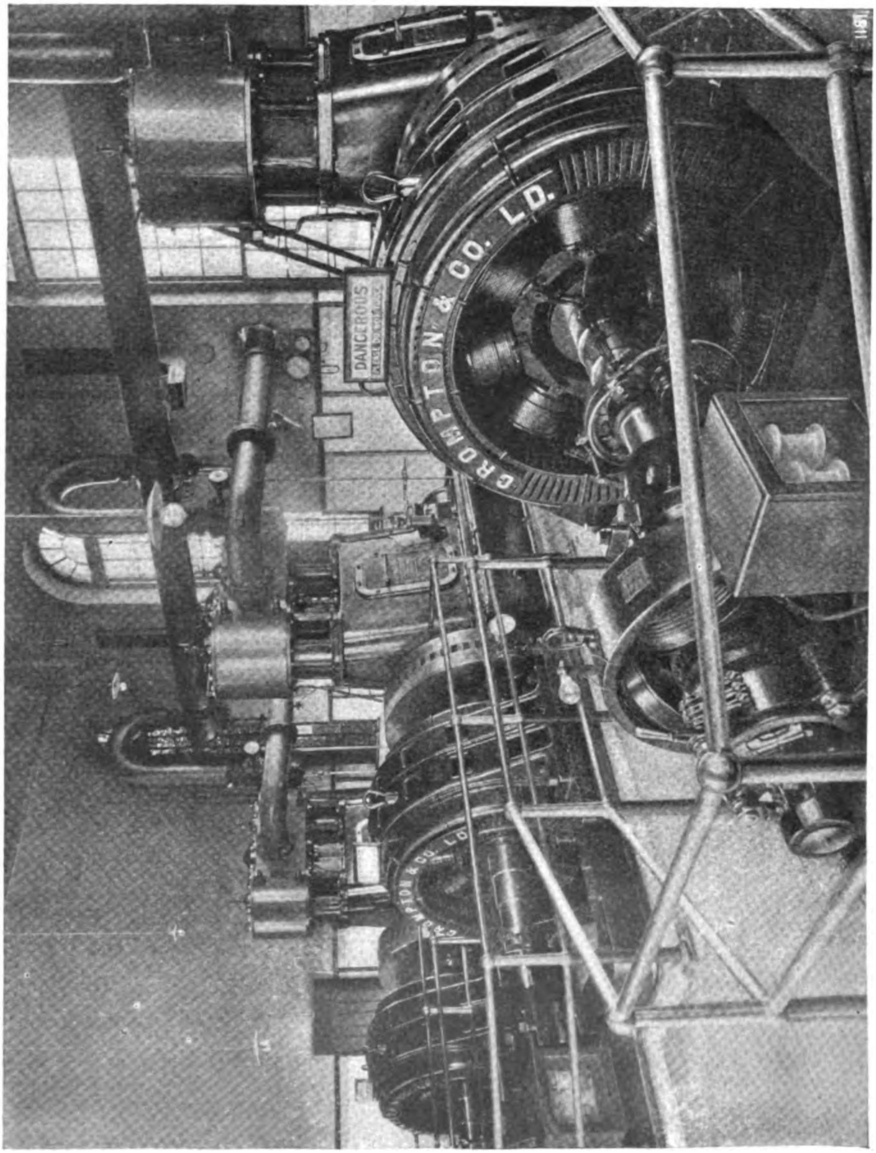


Fig. 1. Interior of the Power Station at the Mountain Ash Collieries.

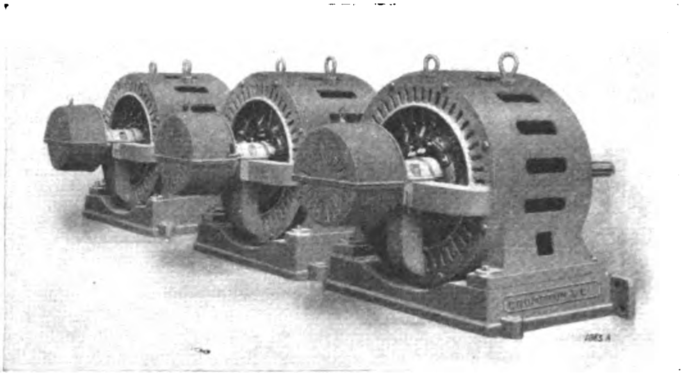


Fig. 2. Group of Three Crompton 250h.p. Three-phase Motors.

the roads, the electrical machinery would be the last part of the gear to suffer.

There are at present two pumps, built by the Uskside Engineering Company, erected in a new pump room on a lower level. The pump room has been very carefully designed and built, and is lined with glazed bricks; it is in every way suited to the class of machinery in it, and contrasts most favourably with the pump houses in which electrical machinery has to be fixed in many other collieries. Each of these pumps is capable of delivering 400 gallons of water per minute against a head of 1500ft., and is driven by a 250b.h.p. three-phase motor running at 490r.p.m. These motors are similar in construction to those used for the haulage gears.

There is also a single-lift winding gear in a staple pit, driven by a 75b.h.p. motor, and there are two blocking engine reversing gears, each driven by a 40b.h.p. motor.

The Bwilfa Collieries, South Wales.

Another colliery installation that has lately been put down by Messrs. Crompton & Co. in South Wales is at the Bwilfa Collieries. This work has also been carried out to the instructions of Mr. Beith of Pontypridd.

The generating plant consists of two steam alternators, the engines being by Messrs. Belliss & Morcom and the generators of Messrs. Crompton's usual design, as shown in the illustration Fig. 3. The output of each generator is 500kw., with a power factor of .8. The system of supply is three-phase alternating at a pressure of 2000 volts per phase. Each set has its exciter directly coupled to the main shaft.

A main switchboard of similar design to that supplied to Nixon's Collieries and described above is provided. From the main board the power is led direct to two large fans used for the main ventilation of the mine. Each fan is coupled direct to a 200b.h.p. three-phase motor running at 415r.p.m. and supplied with current at the 2000-volt pressure as generated.

In concluding this special number of The Electrical Magazine we have to advise readers and contributors that the exigencies of time and space have compelled us to hold over to another issue a very considerable quantity of information relating to the subject of Electric Power in Collieries, and which we would otherwise have been pleased to publish this month. The chief labour in compiling this number has centred in the selection, from the great store available, of that which is most typical of modern practice and which will be of the greatest interest and value to the majority. Doubtless there will be many connected with collieries who will through this number make their first acquaintance with The Electrical Magazine; they should know that future numbers of this journal will contain articles of the greatest value to them in their business.

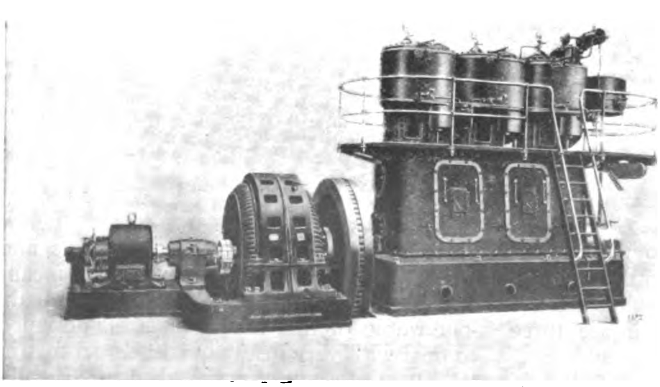


Fig. 3. Belliss-Crompton Generating Set, 500kw., as Installed at the Bwilfa Collieries.

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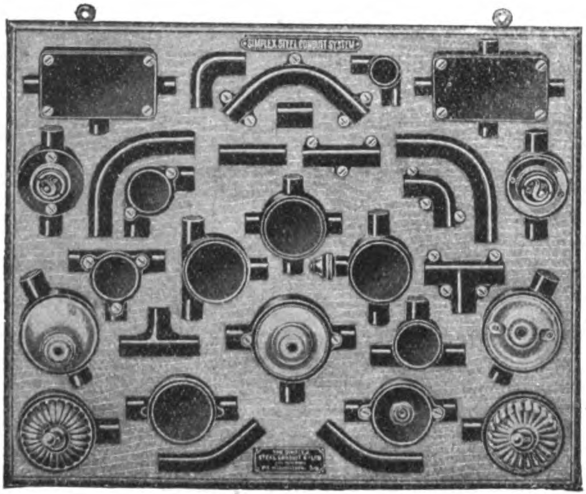

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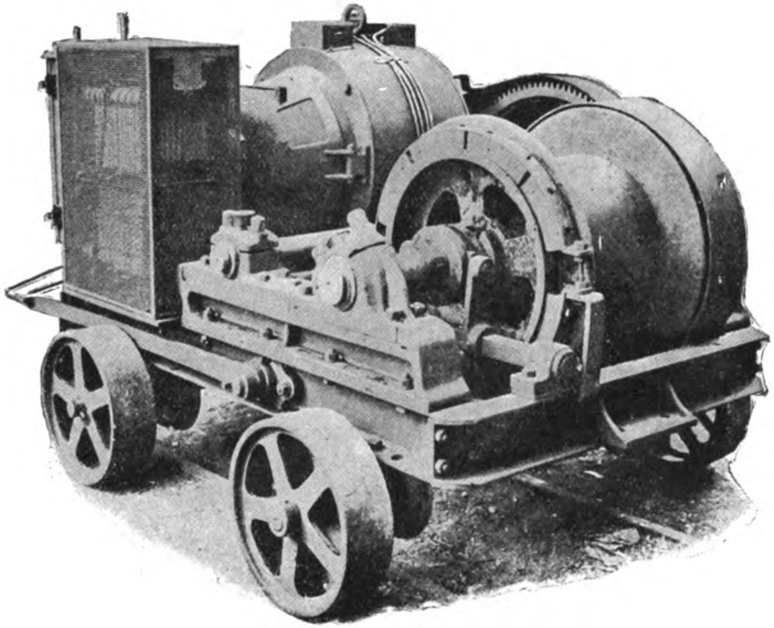

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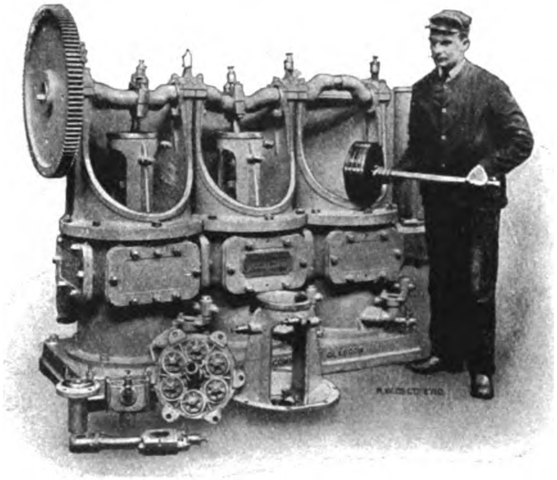

All Working Parts of one Pump were removed as illustrated in 13 Minutes from shutting down, and were replaced ready for running in 46 Minutes.

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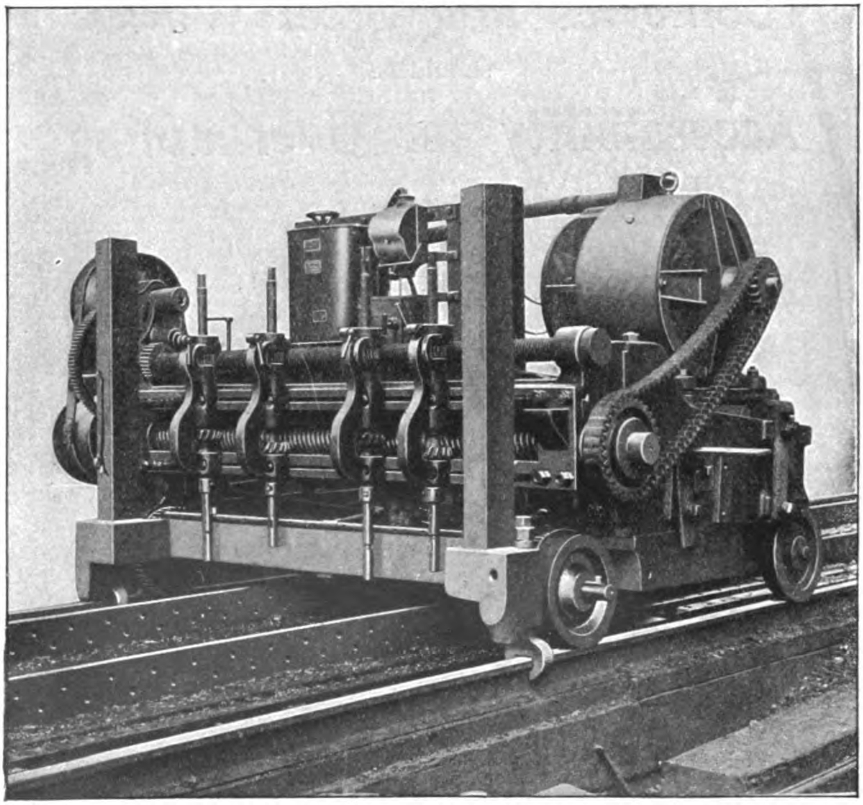

THIS ILLUSTRATION shows one of our "**CASTLE**" Multipolar **15 H.P.** Direct Current **MOTORS**, driving through Chain on to a **TRAVELLING MULTIPLE DRILLING MACHINE.** The Drilling Machine can be equipped with TEN DRILL STOCKS, each capable of Drilling HOLES up to $1\frac{1}{8}$ in. DIAMETER in HEAVY GIRDER PLATES, ANGLES, etc., for BRIDGE and similar WORK. The MOTOR is arranged for VARIABLE SPEEDS to suit the SIZE of HOLES REQUIRED.

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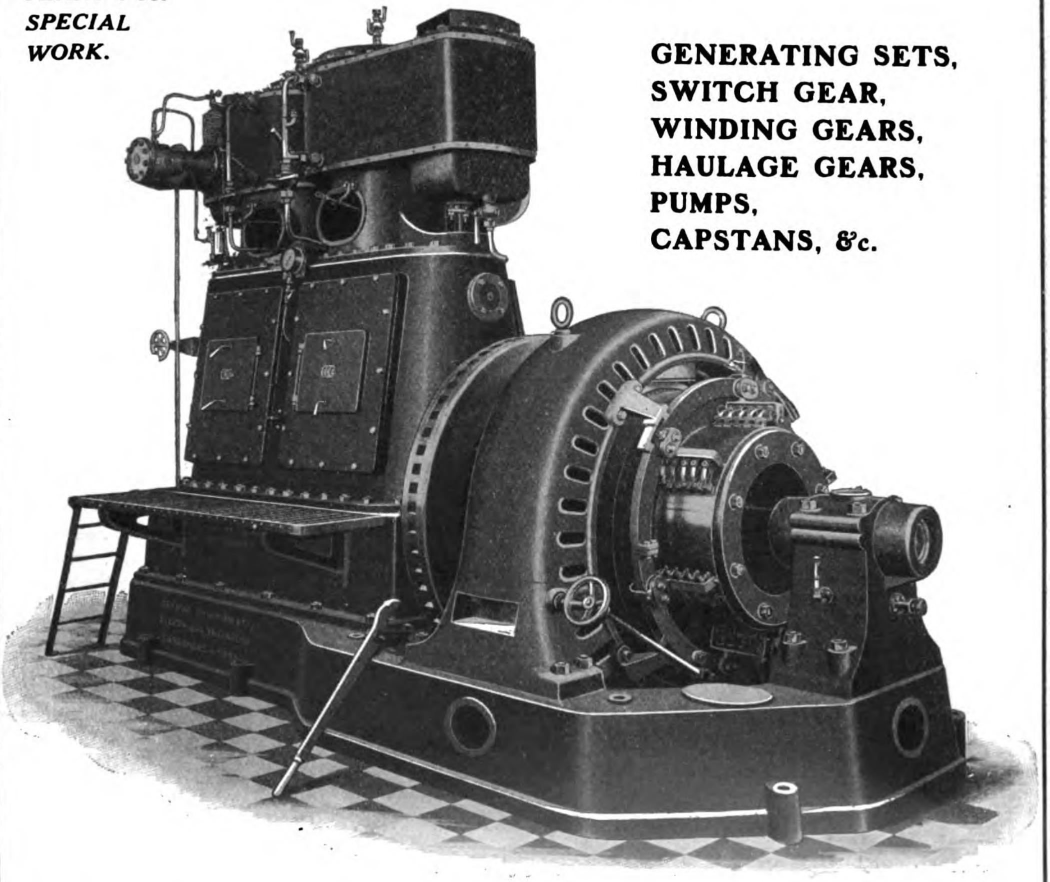

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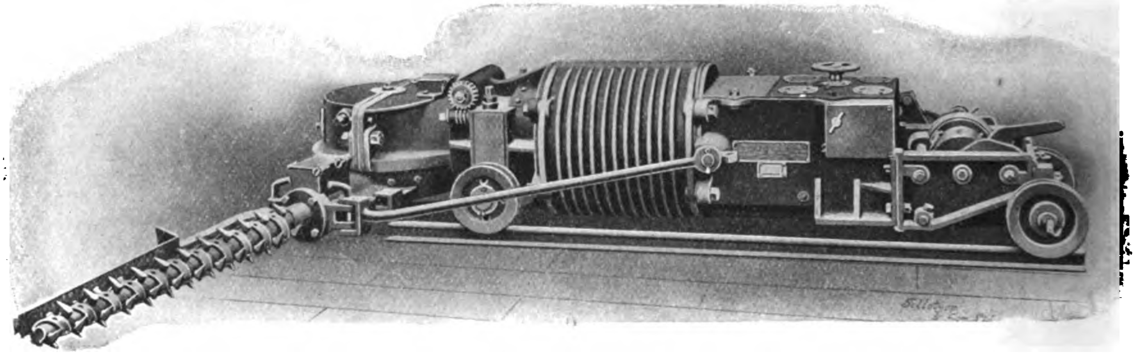

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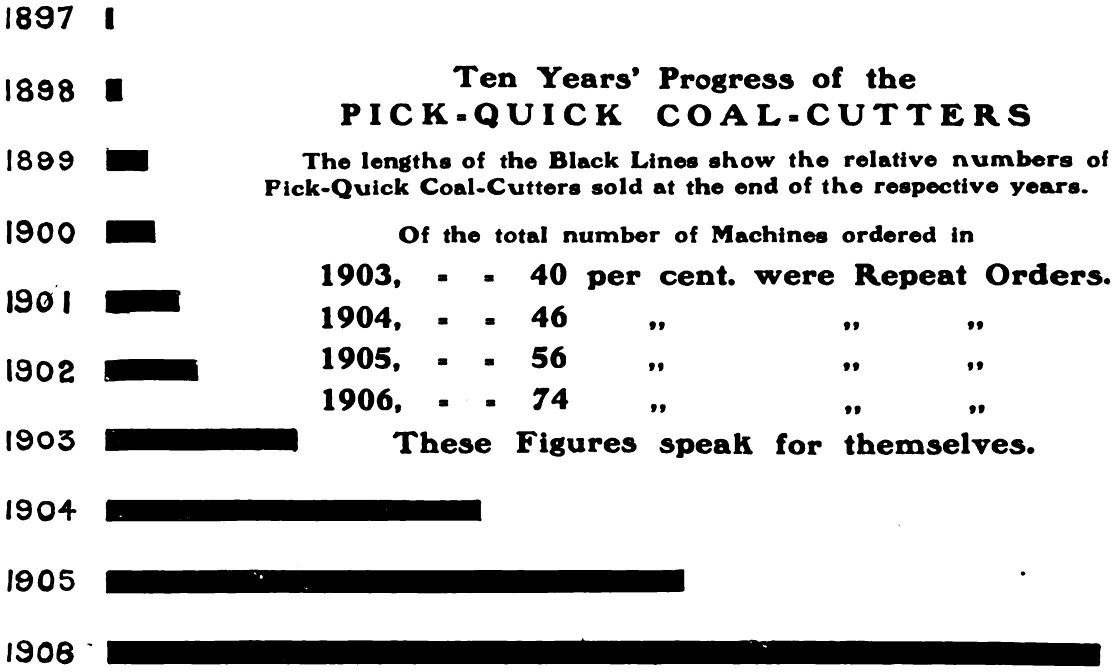

Ten Years' Progress of the PICKQUICK COAL-CUTTERS

The lengths of the Black Lines show the relative numbers of Pick-Quick Coal-Cutters sold at the end of the respective years.

Of the total number of Machines ordered in

1903, - - 40 per cent. were Repeat Orders.
1904, - - 46 ,, ,, ,,
1905, - - 56 ,, ,, ,,
1906, - - 74 ,, ,, ,,

These Figures speak for themselves.

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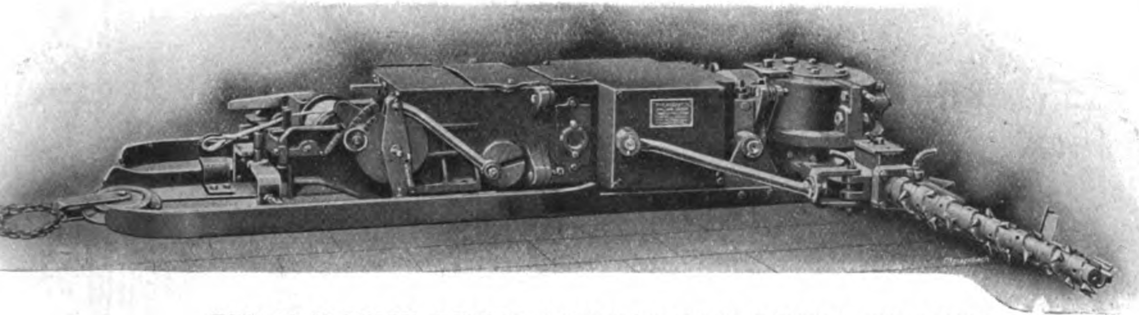

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The PICK-QUICK holds the record for Area Undercut per year and low cost of repairs.

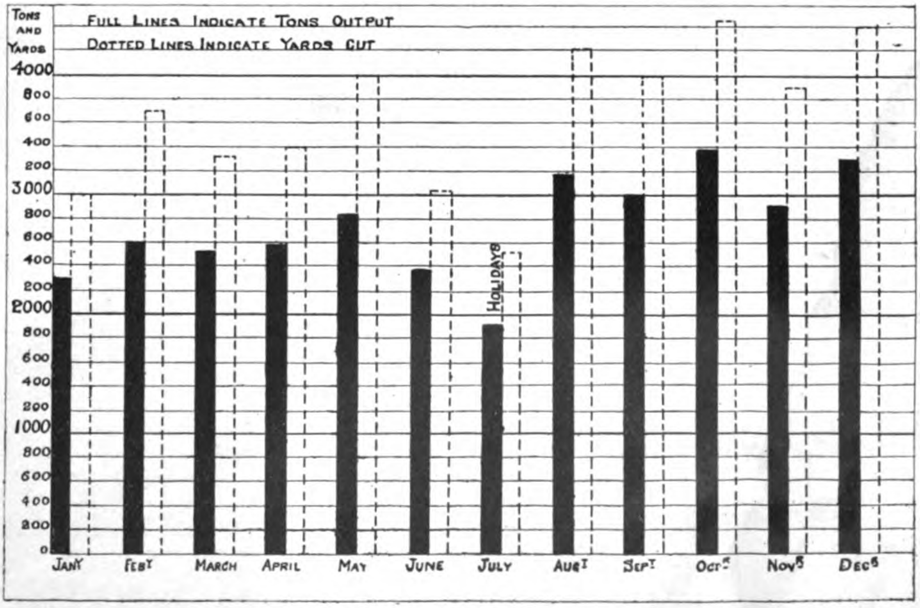
Thickness of Coal **2** Ft. **9** In.	Nature of Holing *Hard Coal & Ironstone Balls*	Thickness of Dirt Bands **9** Inches	Yield per Lineal Yard **15** Cwts.	Length of Face **230** Yards
Distance Cut per Shift **230** Yards.	Depth of Cut **3** Ft. **0** In.	Lineal Cutting Speed **15** Inches per Min.	Duration of Cutting Shift **12** Hours	Power Expended by Motor **13.5** B.H.P.

Total Output in 1905
33,180 Tons

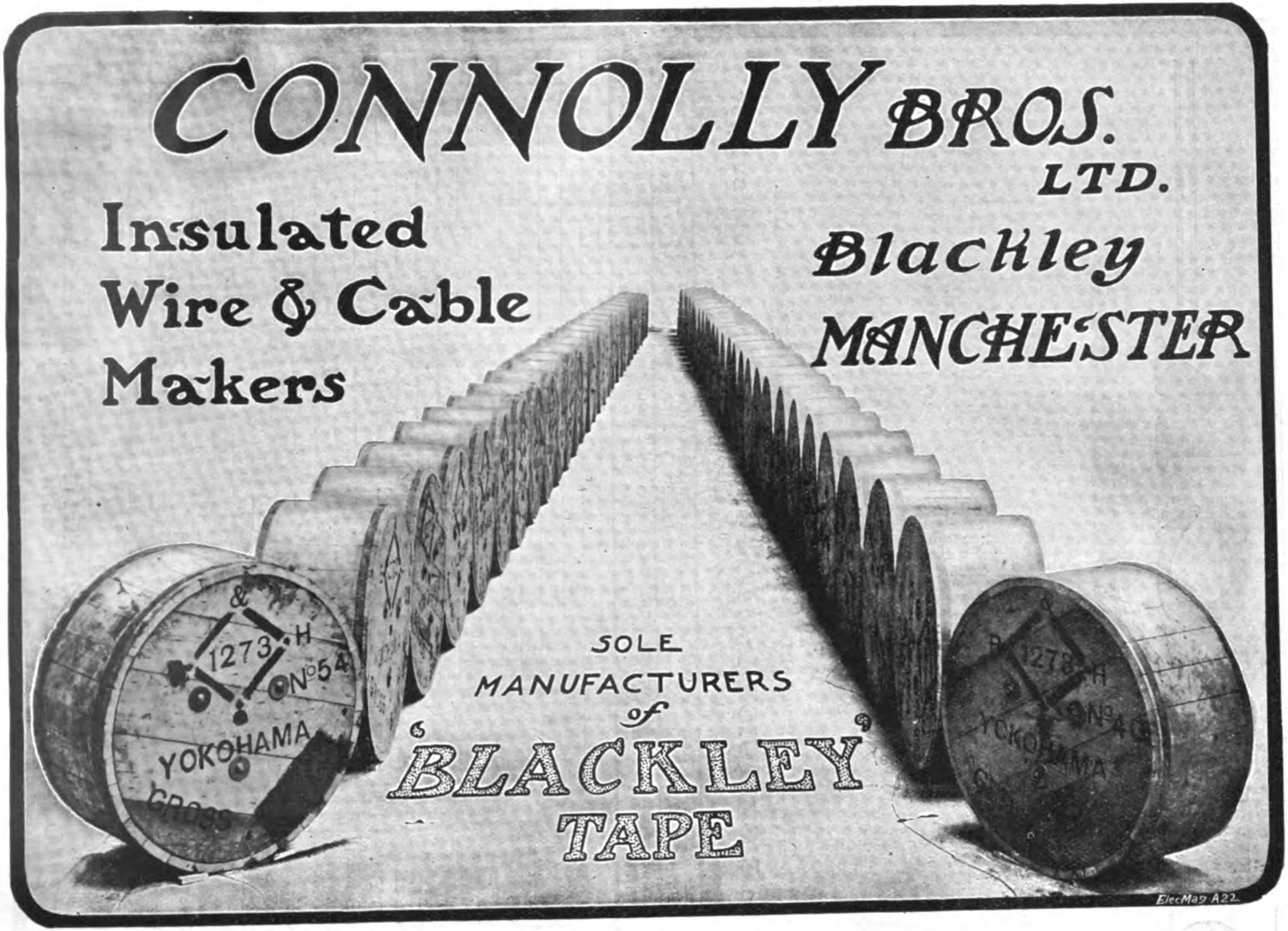
Distance Undercut
44,133 Yds.
=**25.08** Miles

Area Undercut
44,133 Sq. Yds. **9.12** Acres

Cost of Machine Repairs
6d. per **100** Tons Output



The above is not a fanciful diagram but an actual record of work done during the year 1905.



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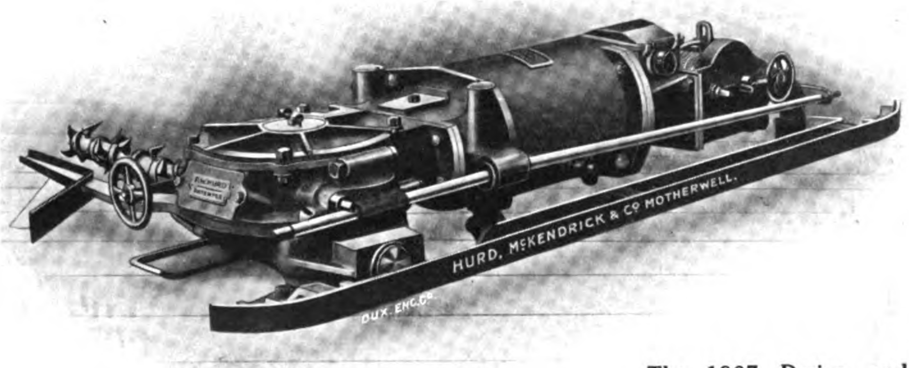

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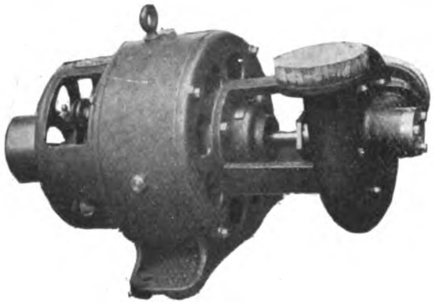

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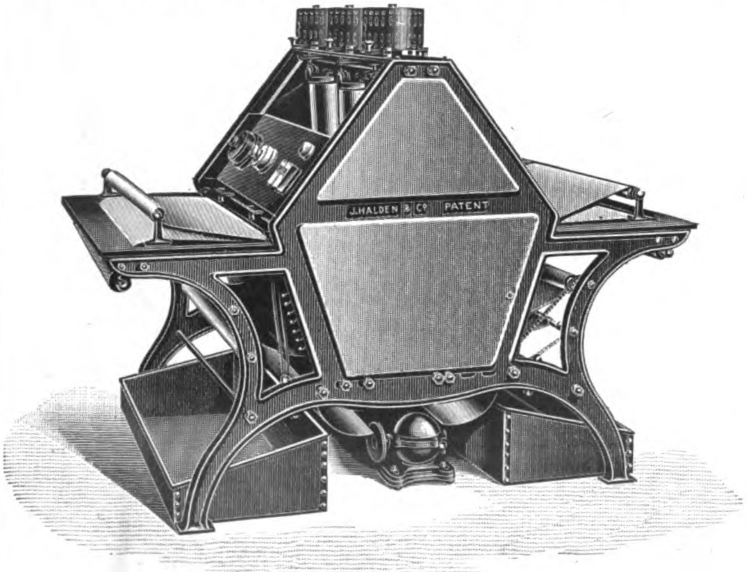

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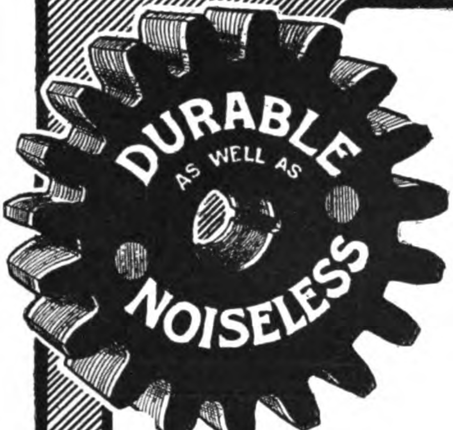

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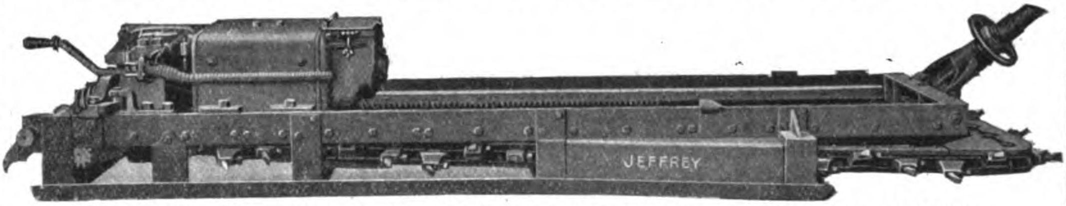

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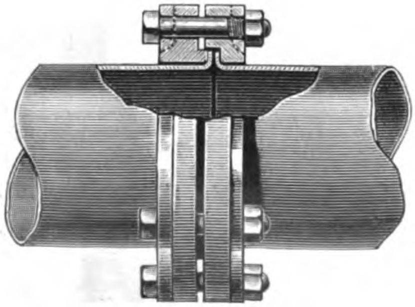

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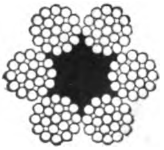

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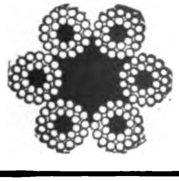

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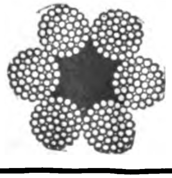

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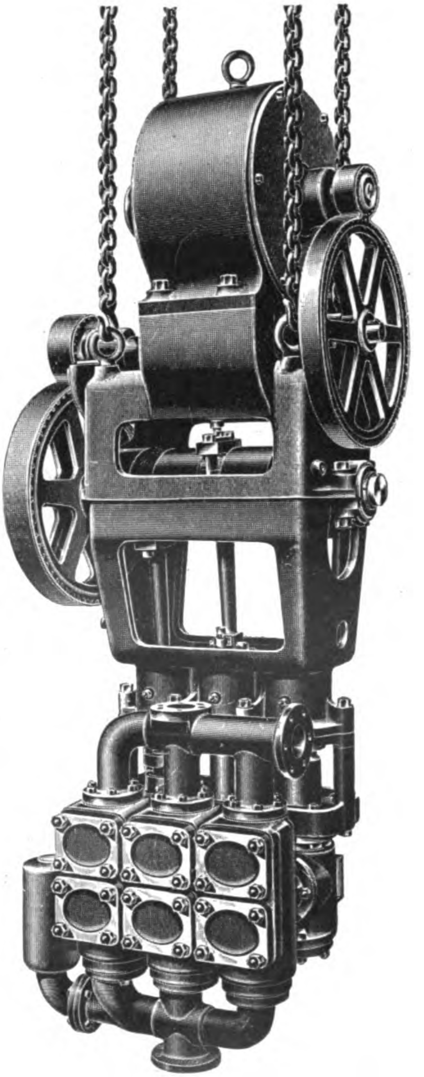

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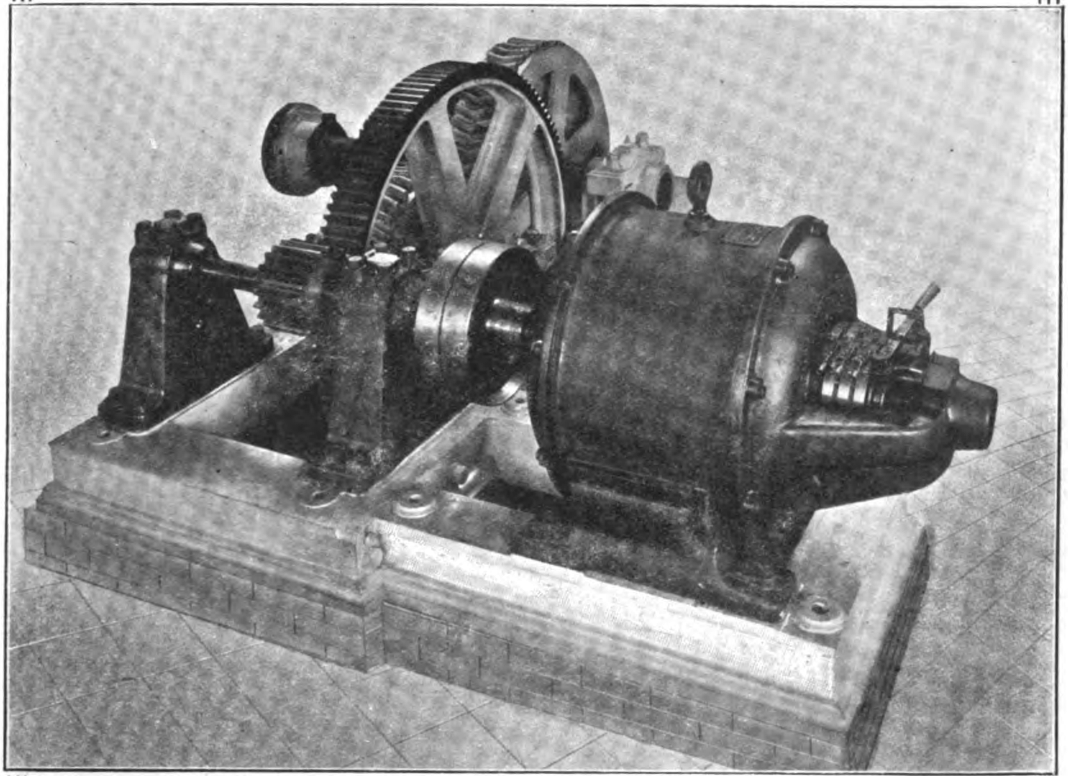

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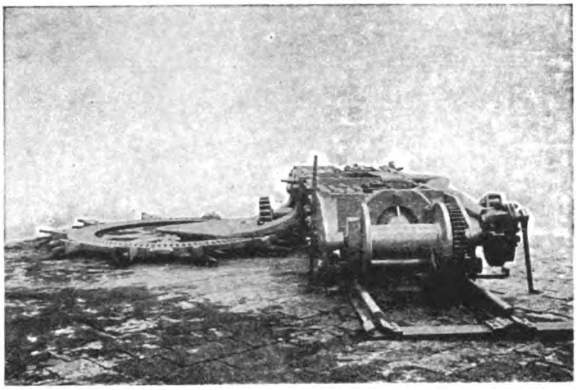

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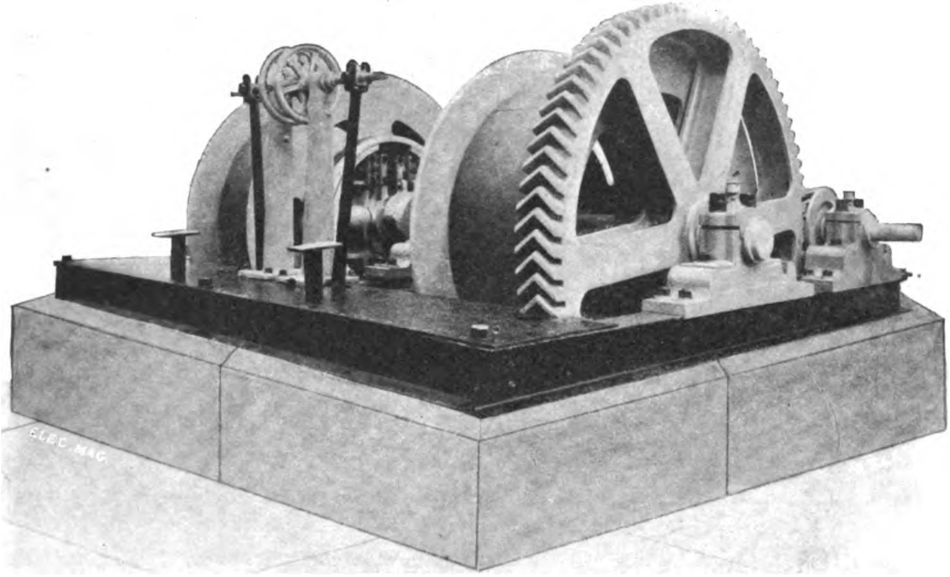

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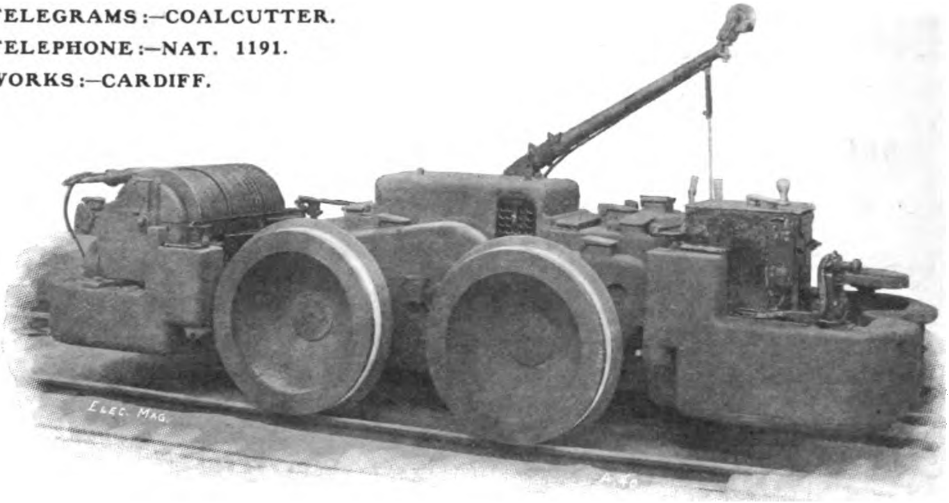

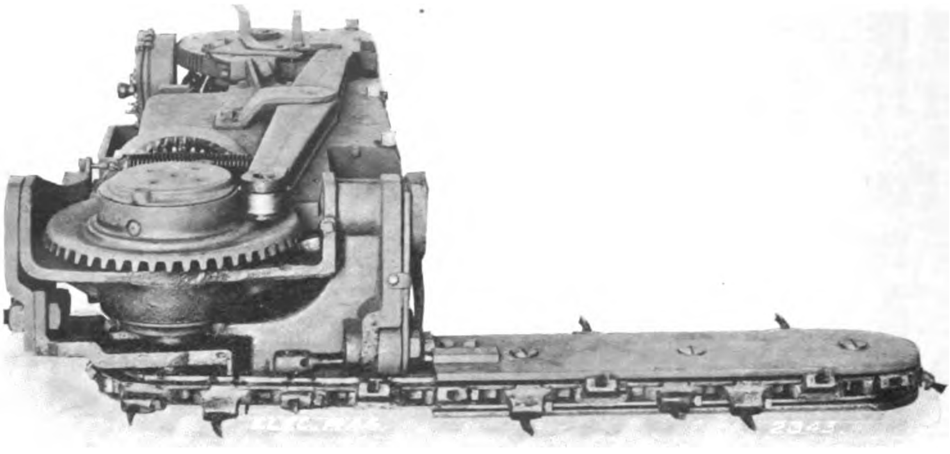

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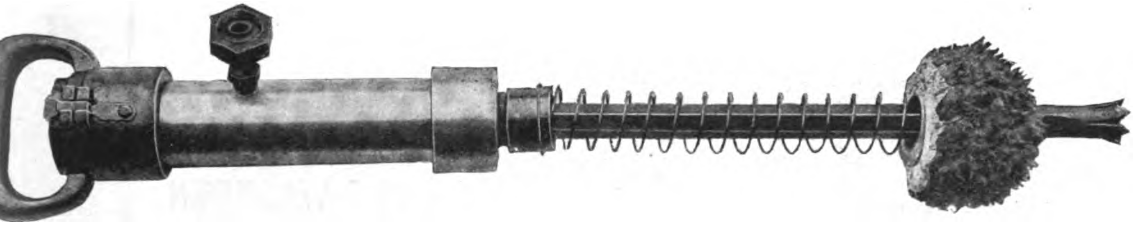

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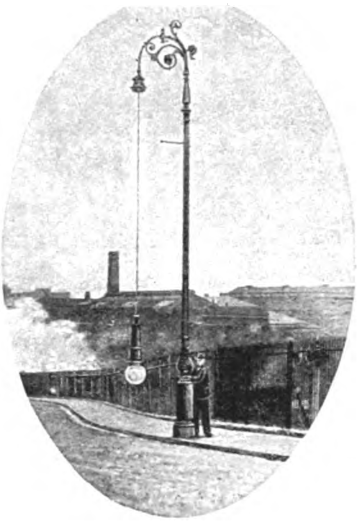

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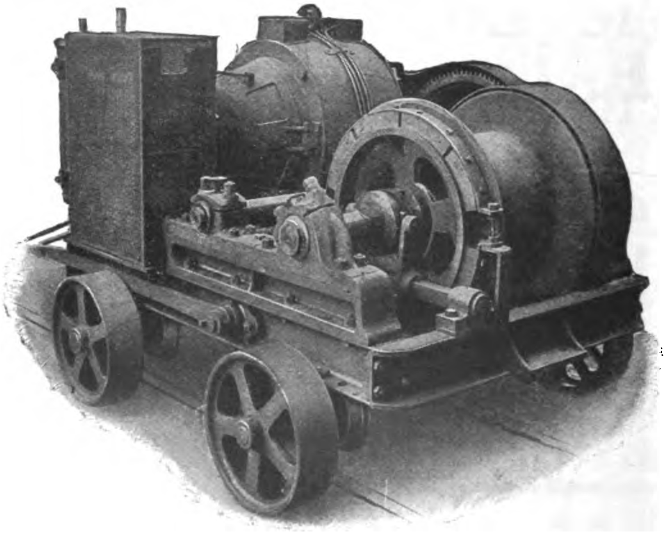

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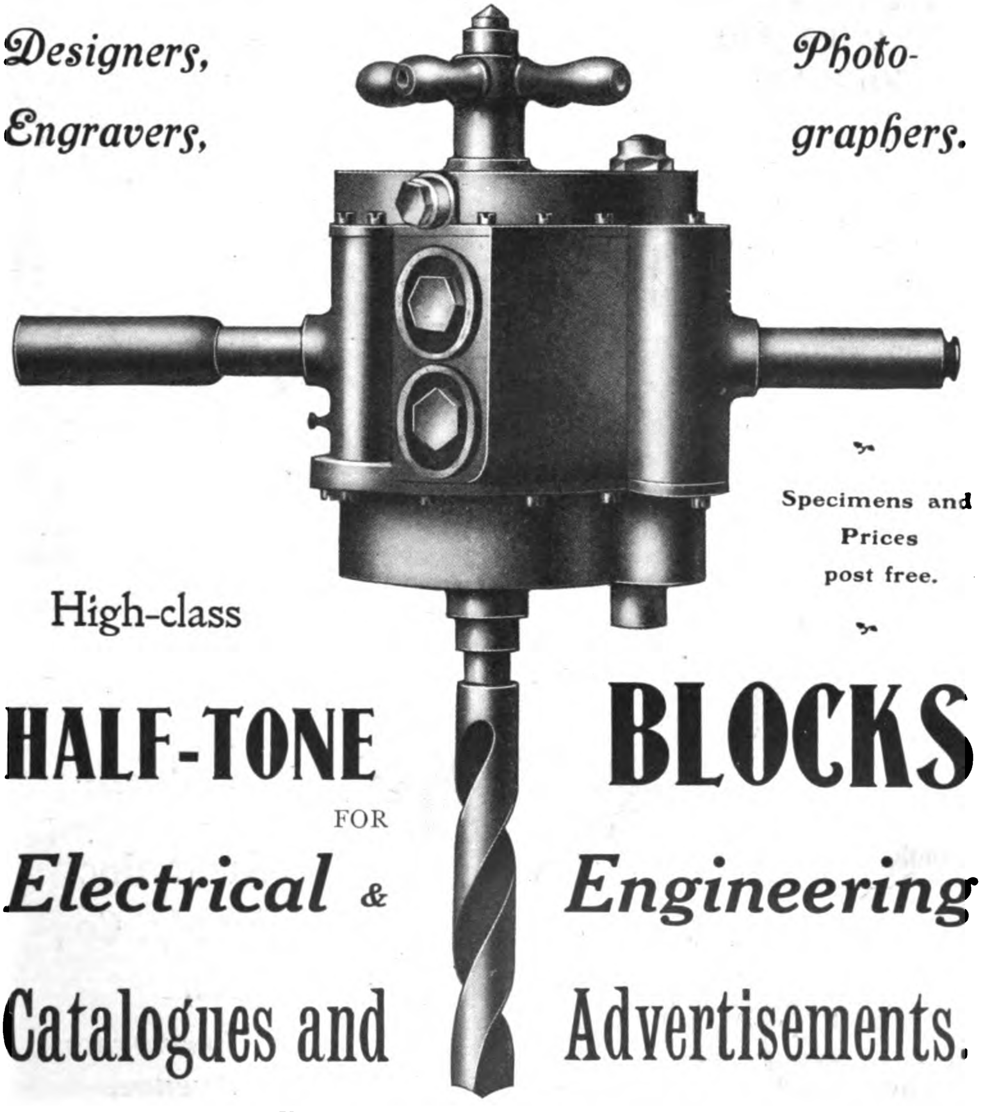

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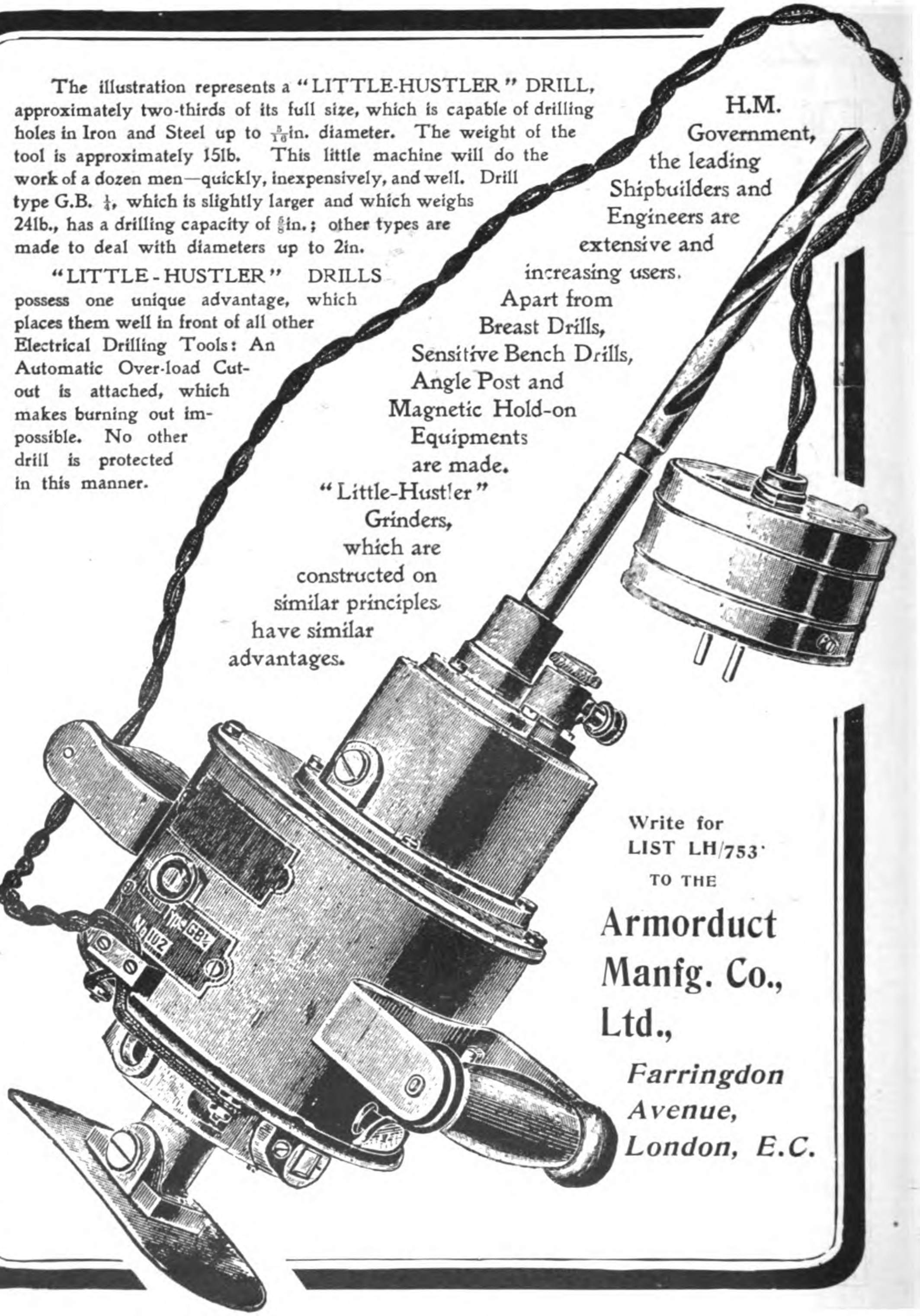

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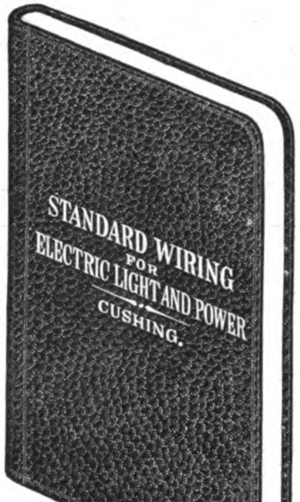

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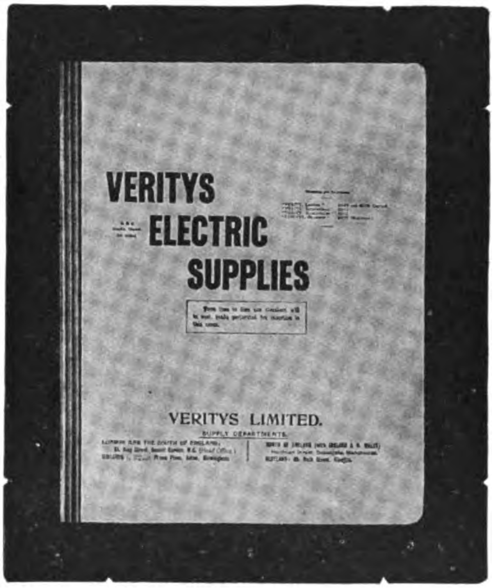

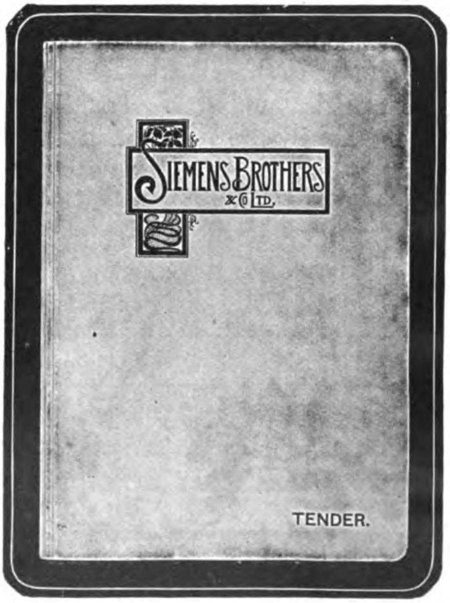

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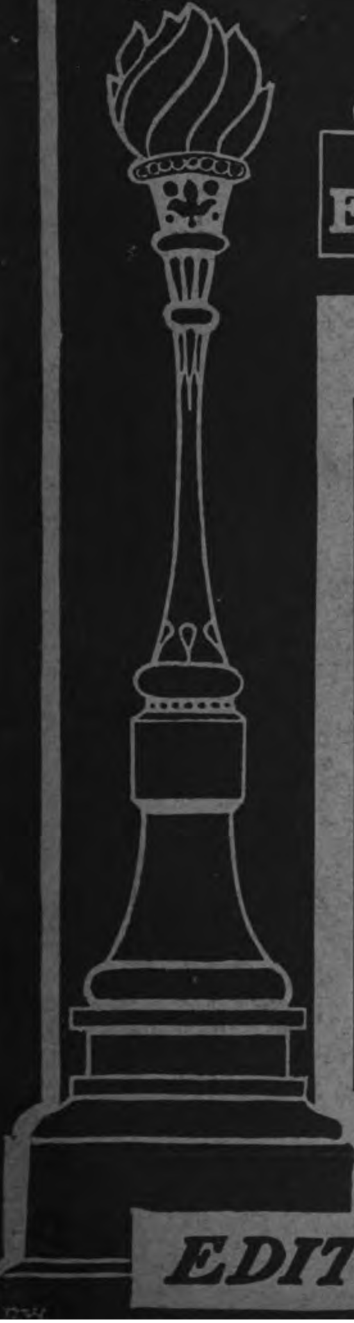

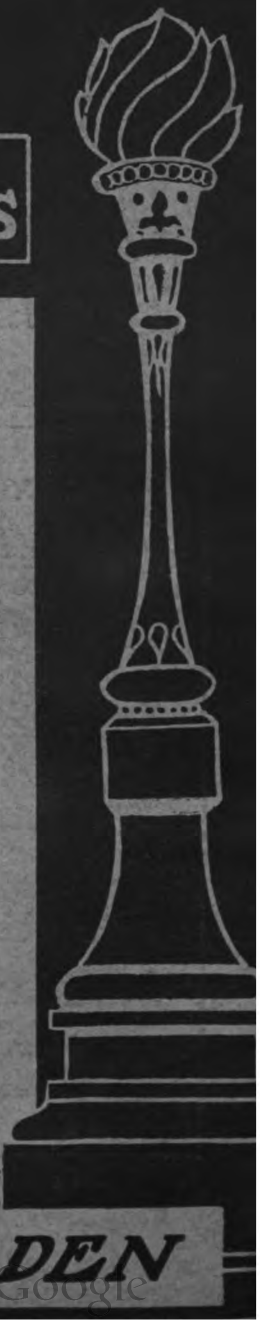

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LITERARY CONTENTS

Of This Issue.

The World's Electric Progress (Editorial) . 249–252
Power and its Application to Industry . 253–257
Traction and Transport 258–260
Central Station Practice 261–266
Lighting and Heating 267–270
Telegraphy and Telephony 271–276
Electrical Design and Manufacture . . 277–283
Electro-Chemistry, Electro-Physics, and Electro-Metallurgy 284–287
Students' Section 288–292
Wiremen's Section 293–294
Manufacturing Progress 295–301
Literary Section 302–303
The World's Electrical Literature . . . 304

PRACTICAL BOOKS

For Engineers, Manufacturers, Contractors, Students, Apprentices, Mechanics, &c., &c.

(See page 28.)

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Index to Advertisers.

For specialities and manufactures of firms below, see preceding Buyers' Guide.

	PAGE
A. E. G. Electrical Co. of South Africa, Ltd.	11
A. E. G. English Manufacturing Co., Ltd.	
Adams Manufacturing Co., Ltd.	
Angus, George, & Co., Ltd.	
Armorduct Manufacturing Co., Ltd.	
Automatic Standard Screw Co.	ii. of cover
Babcock & Wilcox, Ltd.	7
Bennis, Ed., & Co., Ltd.	
British Steam Specialties, Ltd.	
British Westinghouse Electric & Mfg. Co., Ltd.	
Broadbent, Thos., & Sons, Ltd.	
Campbell Gas Engine Co., Ltd.	
Clarke, Chapman & Co., Ltd.	7
Connolly Brothers, Ltd.	19
Corlett Electrical Engineering Co., Ltd.	
Craven Bros., Ltd.	
Crompton & Co., Ltd.	13
Crypto Electrical Co.	
Cundall, Sons & Co., Ltd.	
"Cyclopædia of Applied Electricity"	
Davis, John, & Son (Derby), Ltd.	
Diamond Coal Cutter Co.	
Diesel Engine Co., Ltd.	10
Electric & Ordnance Accessories Co., Ltd.	
Electromotors, Ltd.	
Engineering and Machinery Exhibition	27
Ferranti, Ltd.	
General Electric Co., Ltd.	
Glaholm & Robson, Ltd.	
Goodman Manufacturing Co., Ltd.	8 and 9
Green, E., & Son, Ltd.	16
Halden, J., & Co.	
Hall, B. J., & Co., Ltd.	
Hannan & Buchanan	
Hardy Patent Pick Co., Ltd.	ii of cover

(*Continued on page 6.*)

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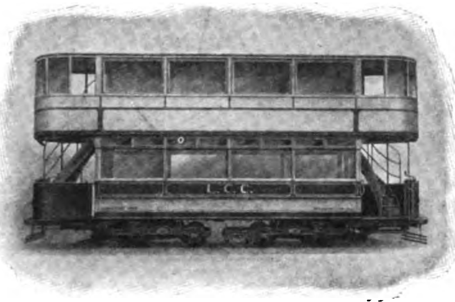

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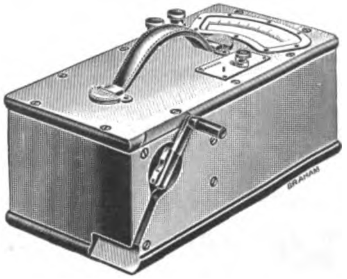

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Index to Advertisers—continued.

	PAGE
Hendry, James	iii of cover
High Speed Braiding Machine Co., Ltd.	
Holmes, J. H., & Co.	
Hornsby, Richard, & Sons, Ltd.	
Howden, James, & Co.	
Hurd, McKendrick & Co.	
Hyatt Roller Bearing Co.	
India-Rubber, Gutta-Percha, & Tel. Wks. Co., Ltd.	12
Industrial Engineering and Motor Co., Ltd.	
Lancaster & Tonge, Ltd.	
London & County Printing Works	32
Macintyre, James, & Co., Ltd.	
Mather & Platt, Ltd.	23
Mavor & Coulson, Ltd.	
McGeoch, Wm., & Co., Ltd.	17
Meldrum Bros, Ltd.	
Mirrlees Watson Co., Ltd.	
"Modern Electric Practice"	
"Modern Engines and Power Generators"	
"Modern Mining Practice"	29
Mountain & Gibson, Ltd.	5
Nalder Bros. & Thompson, Ltd.	5
Neill, W., & Son, Ltd.	
Newton Bros.	
North-Western Electrical Appliance Co.	
Pearn, Frank, & Co., Ltd.	3
Phillips, Charles D.	24
Phœnix Dynamo Manufacturing Co., Ltd.	
Pinchin, Johnson, & Co., Ltd.	22
Practical Books	28, 30, and 32
"Practical Coal-Mining"	29
Press Etching Co.	26
Pritchetts & Gold, Ltd.	
Reason Manufacturing Co., Ltd.	15
Rhodes Electrical Manufacturing Co., Ltd.	
Ross, R. G., & Son	iii of cover
Sandycroft Foundry Co., Ltd.	25
Santoni, D., & Co. (1906), Ltd.	
Simmonds Bros., Ltd.	iii of cover
Simplex Conduits, Ltd.	24
Smith (A.) and Stevens.	
"Standard Wiring"	31
Stewarts & Lloyds, Ltd.	
Stirk, John, & Sons	
Stolzenberg Patent File Co.	21
Suter, Frank, & Co., Ltd.	14
Switchgear Co., Ltd.	
Temperley Transporter Co.	
Thames Ironworks, Shipbuilding and Engineering Co., Ltd.	
Thom, John G.	iv of cover
Turnbull, Alex., & Co., Ltd.	16
Union Electric Co., Ltd.	17
United States Metallic Packing Co., Ltd.	3
Waygood, R., & Co., Ltd.	24
Wild, M. B., & Co., Ltd.	
Winn, Charles, & Co.	
"The World of To-day"	
"World's Work"	31

Important Announcement.

The next special issue of The ELECTRICAL MAGAZINE will be mainly devoted to Electrical Applications in the Textile Industries. It will be published either in June or July, and it is intended to make it the most important contribution to the subject yet presented. Its contents will be of intense interest not only to Electrical men but to all those identified with the Textile Trades. Arrangements are being made with leading experts to supply special articles on the Electric driving of Cotton, Silk, Jute, Flax, and Woollen Mills. The Number will be profusely illustrated from extremely interesting photographs exclusively taken for this Journal.

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You will find the List of Technical Books (with particulars and prices) given in this Issue invaluable to you. (See page 28 at end.)

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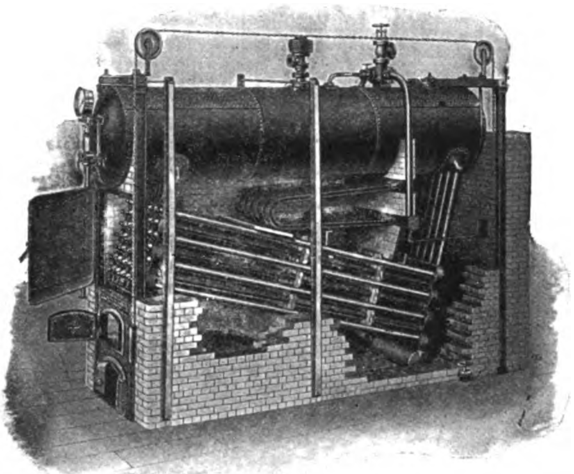

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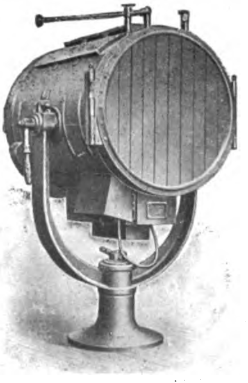

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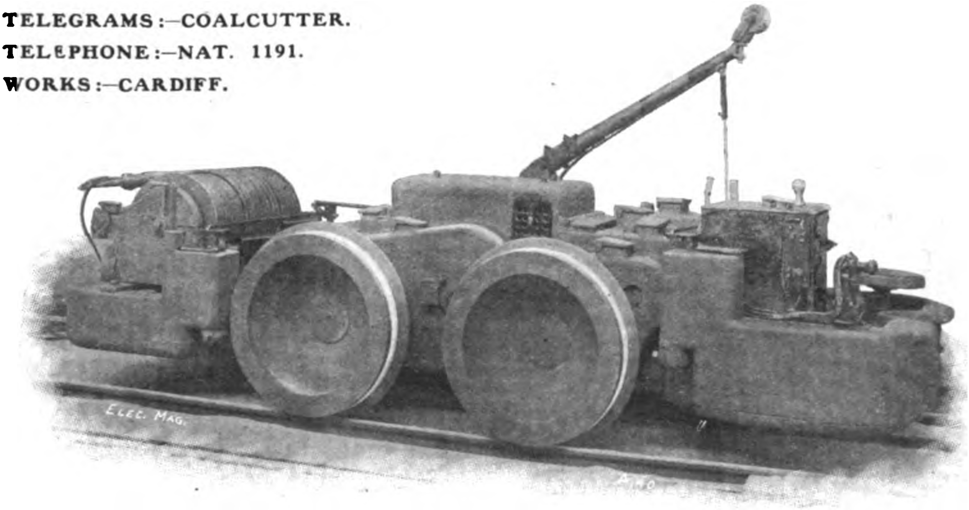

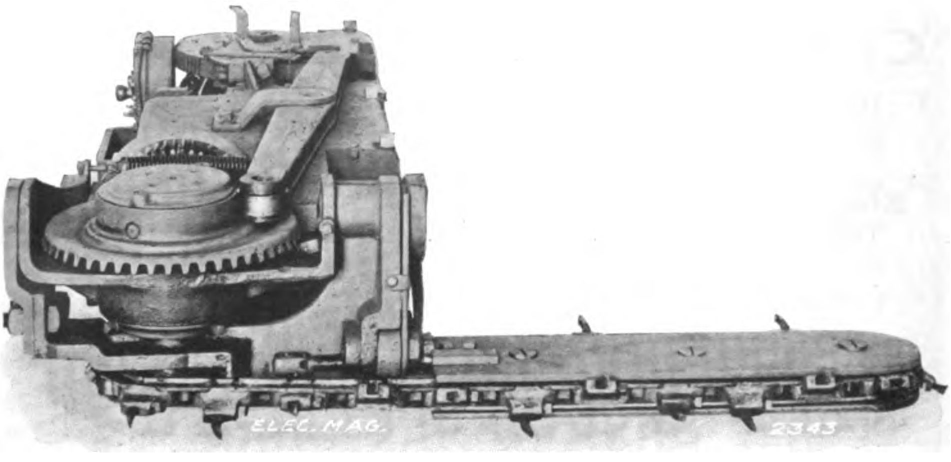

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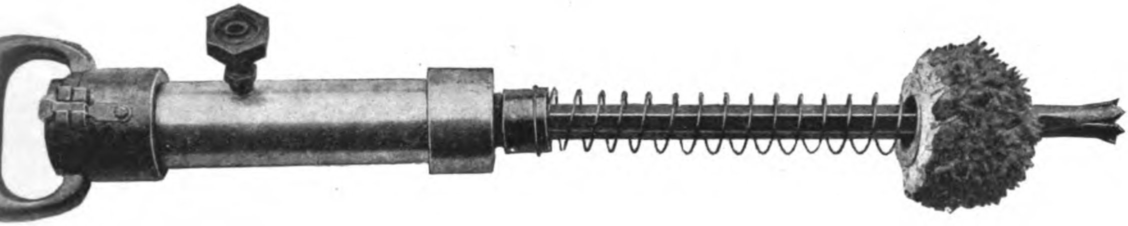

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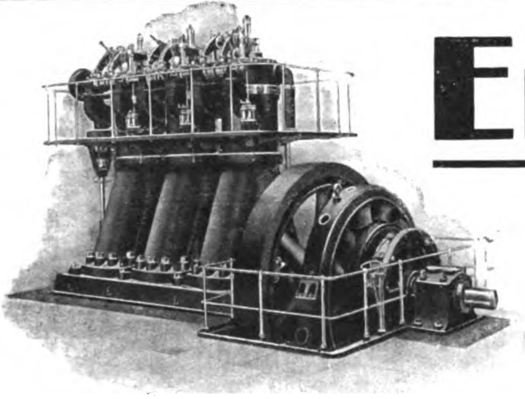

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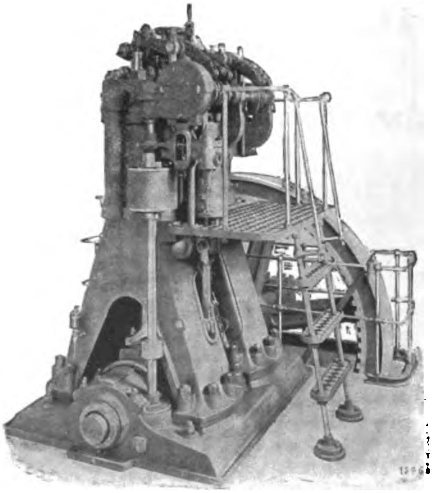

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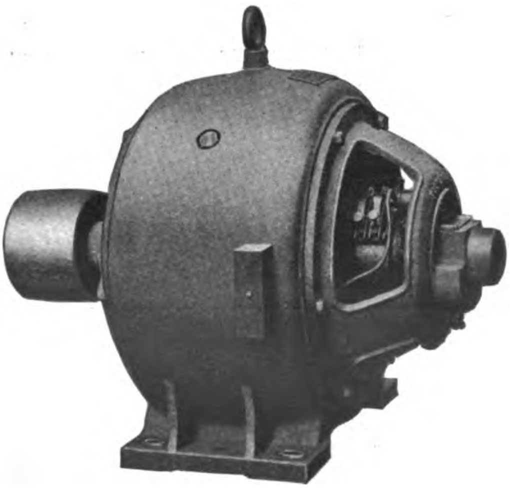

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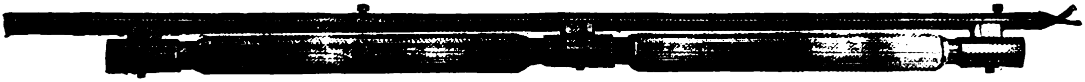

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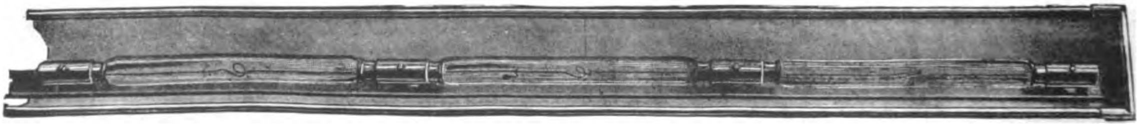

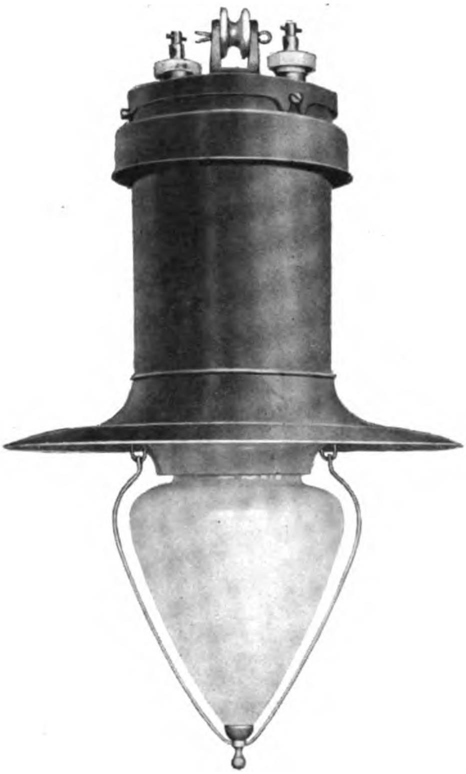

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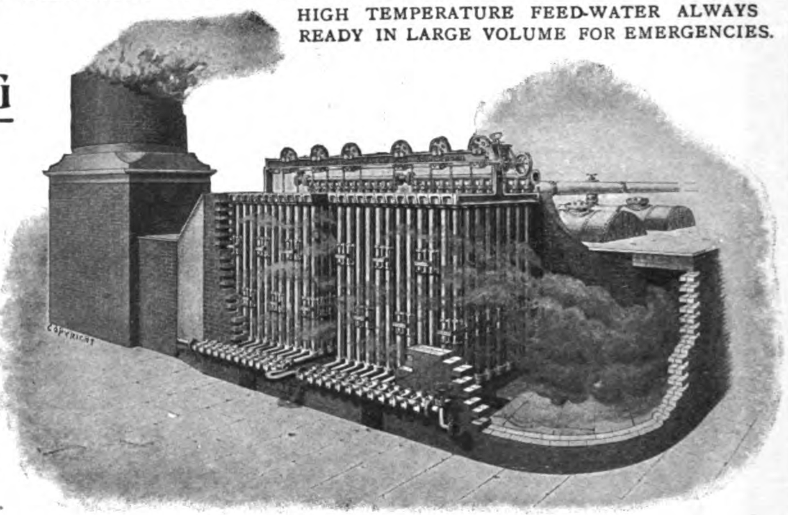

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The Electrical Magazine.

FOUNDED AND EDITED BY
THEO. FEILDEN.

VOL. VII. No. 4. (40th Issue.) LONDON. APRIL 30th, 1907.

The World's Electric Progress.

Is the City Tramway Obsolete?

THE motor-vehicle is now applied to every class of road transit; public and private passenger service, as well as all grades and weights of goods and merchandise, are handled perfectly by the ever and rapidly improving "motor." It has long been conceded that the horse as a traction motor is dropping out of civilisation and indeed it is a present-day wonder that it has remained in favour so long after the discovery of engine power. But there is a more important change threatened: seeing the motor-'bus, van, carriage, cycle, or wagon on every hand, reading the complaints that tube and suburban railways and tramways are levelling at the motor-vehicle competition, forces one to consider seriously and with some misgivings the future of the tramway. Has the electric tramway reached its zenith?

Considering the why and wherefore of tramways, the first point to be remembered is that rail-traction was introduced to our streets as a means of providing just sufficient smooth-surfaced track as would permit the horse to draw a comparatively comfortable passenger car at a fairly high speed for a goodly number of hours per day with the minimum of effort. In short, the trouble leading to the birth of the tramway was bad roads. Even when steam-cars came into vogue the tram-lines were retained, and looking back now it is difficult to see any really important reason why this should have been so; it would rather appear as if when the steam-tram was introduced the motor-'bus was missed by mere chance. It was however, not till many years afterwards, and not until very large sums of money had melted into thousands of miles of ever-increasingly expensive and elaborate street tramways, that the quick-running motor vehicle, for which the entire width of the road afforded sufficiently good surface, came into being. The unfortunate part of the tramway development has been that the rails have become an essential and indispensable part of the system; they are now not merely the smooth and narrow way to gently guide the car. These very rails of the modern electric tramway, confining the trams to definite routes and interfering with their progression through other street traffic, are fast being recognised as unnecessary in these days of good surfaced streets, and as a serious impediment and nuisance in city thoroughfares.

It is generally understood that the motor-'bus has come to stay—public appreciation has already demonstrated so much. Without going closely into details of electric tramway and motor-'bus comparisons it can be said that the important difference is in the respective costs of operation. The tramway is superior on this count, but it is undeniable that, with continued experience, the motor-'bus will nullify this difference. The public has declared for the motor-'bus with its free choice of route, its unlimited service, its speed, and its low fares. The engineer can be depended upon to develop the vehicle and organize its traffic to a good paying standard. Looking at the question as one may, and with the interested view of an electric tramway partisan, there would appear to be a return to rail-less city streets imminent. It is of course only for passenger service in the crowded streets of cities and towns that this change is really threatening; for suburban routes and interurban connections the electric tramway is in no danger of extinction, that is to say possible changes in this direction are not within sight, and we are not interested in vague prophecies at this writing.

Whilst the electrical engineer may have felt some concern as to tramway prospects when visiting the important motor-car exhibitions recently held in London, he had at all events good consolation at hand, as witness the ever-increasing use of electrical motive power for road vehicles. Petrol-electric and all-electric equipments are coming rapidly to the forefront. Many of the leading British electrical manufacturers are specialising in the design and construction of motor-car electrical plant, and even of complete vehicles. In other cases, engineers are engaged in exploiting the rail-less electric tram, if we may so term the vehicle which, receiving its current supply from a double overhead trolley system, is free to run on any part of the road under steering control.

To say definitely whether the city tramway systems and electric tube railways will continue to prosper or not would be presumption, but we have said sufficient to show that any increase in number or extent in either of these directions is to-day fraught with a considerable proportion of risk, and demands exceptional sagacity and forethought on the part of those interested.

Any discussion of tramway matters cannot, in this country, keep clear of the municipal control question. That this phase of the subject has very largely to do with the future of street traction cannot be gainsaid. It is equally certain that the tramway-owning borough has hampered, and will for some time continue to hinder the development of company-controlled motor-'bus enterprise. It may even be that the slow-going municipality, which has not yet nerved itself to the extent of acquiring a municipal tramway, will come out better than its neighbours in the long run by starting in with a rate-owned motor-'bus system.

There are very many debatable points entering into the subject of present-day city traction. Every thinking person, whether engineer or layman, has his own ideas as to what is the most common-sense and promising method of dealing with passenger traffic in and around the busy centres of industry.

We shall be pleased to have readers submit us their views and opinions on the matter, which will as far as possible be published in our columns, and which will help towards giving an answer to the query of our title.

❧

Engineering Apprenticeship.

The glamour of electrical engineering still appeals strongly to the youth ready for business, and there is no occasion to complain of lack of recruits for the electrical side of engineering, despite the fact that it is not infrequently said that the industry has become overcrowded. We are not concerned at the moment with the latter contention, but, to prevent misunderstanding, we should say in passing that there is still unlimited scope for the worker who enters the electrical field. Whilst the article dealing with matters of apprenticeship which appears in this number under the Students' Section is American and owed its origin to an apparent lack of entries for the engineering works, it is of more than average interest and should be given careful consideration by readers—employers and employed alike.

Although the theme discussed was as to how the engineering business could be made more attractive to the prospective apprentice, the result has been to extract opinions and facts as to the best way to train apprentices for the greatest advantage to themselves and the industry.

The most original of the several schemes, that of draughting senior schoolboys into the shops for a portion of their school-day, the works training to form a part of their school education, has some favourable points, but on the whole can hardly be considered as worth general adoption. It reminds one of the "half-timer" of the cotton factory, our old and universally-condemned system. We do not suppose that conditions akin to those suggested are being installed in America; indeed, the ages of schoolboys and would-be apprentices as mentioned in the article would preclude the stigma of "child-slavery." Yet any system entailing part school and part works is objectionable; the two forms of training do not agree, they clash with each other, and the effect is that neither at school nor in the shops is good progress made. In this we do not of course when speaking of school imply technical colleges and similar institutions, but simply the ordinary day-school.

It is noteworthy that the whole of the suggestions for improvement depend to a greater or less degree upon technical education. Might it not be that in this the wrong principle altogether is being advocated? Is it not a natural outcome of such training that the apprentice is led to expect more than a mere *trade*? Does not the combination of skill in handicraft with theoretical book knowledge endow him with a *profession*? When he reaches this stage, unless a leading position is forthcoming, does he not as a disappointed man abandon the "overcrowded profession" in disgust?

These are some potent questions which readers can readily answer for themselves. It is at all events very certain that many of the most successful electrical engineers of to-day were developed simply as wage-earning trade-apprentices who in spare time devoted themselves to technical study.

We are thus directed to the question of premium *versus* wage-earning apprentices, and there can be no doubt as to which of the suggested reforms in the article under notice is the most likely to encourage recruits to engineering. The remarks of Mr. H. K. Hathaway, who tells of apprentices receiving wages the equivalent of 35s. to 45s. per week, offer the most practical solution of the apprenticeship question.

It is, to say the least, remarkable that there are still many electrical firms who demand premiums with apprentices. Considering our previous remarks there would seem to be not the slightest justification for this. Any young man of even indifferent ability earns something almost immediately he enters the shops. He is not assured of any the better position after completing his apprenticeship because he paid a premium and did years of good productive labour without recompense. The reverse is often the case, the premium apprentice is tolerated when a wage-paid junior would be discharged under similar circumstances. It is high time that the premium pupil or apprentice of the electrical works be abolished. Regarding technical education, this should not be provided as such by the works owner as a part of the apprentice's training. Nor should technical studies be compulsory in any way; our technical colleges are provided for those who have the energy and ability to apply themselves properly to study with the ultimate object of coming to the forefront. That they can do: the wage-earning apprentice "serving his time" to a *trade* can, with the aid of technical education, rise to such proficiency that he can justly claim to be of the electrical *profession*.

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Colonial Postage Reform.

WITH reference to the editorial which appeared in THE ELECTRICAL MAGAZINE under this heading last month, our readers will doubtless have noticed from the daily press that a remarkable reduction was announced in the House of Commons on the 15th inst. by the Postmaster-General on postage of newspapers and trade journals to Canada, the same to come into operation as and from the 1st prox. This great measure of reform, reducing the postage of all periodicals from 4d. to 1d. per pound, is something which British manufacturers have to be thankful for. They will find as time goes on that it will have a very appreciable influence upon their trade. It will give a tremendous impetus in Canada to the circulations of the various industrial publications emanating from this country, and as advertisement rates, we premise, will not be increased thereby, the resultant benefit will be obvious.

Too long, as we pointed out in our last issue, has the United States held the field in our great Dominion in regard to special facilities for the dissemination of trade literature, in fact of periodical literature of all kinds, and it is due chiefly to the great patriotism and enterprise of the present Postmaster-General of Canada—the Hon. Rodolphe Lemieux—that the present most welcome reform has been brought about. In saying this we have to acknowledge in the fullest possible manner the foresight and sagacity of our own Postmaster-General—the Right Hon. Sydney Buxton—who is, to his great credit, the first Postmaster-General of Great Britain to recognise in a practical manner the necessity of remedying a state of affairs as extraordinary as it has been inimical to the interests of British manufacturers. In saying this we cannot disguise the fact that the step is one of great importance and gravity for any responsible Minister to undertake. It will undoubtedly mean a considerable increase in the permanent staff of the British Post Office in order to cope with the very big accretion of business that is sure to follow almost immediately, and we concede that at the start the Post Office will have to face a fairly large loss on the transaction. We firmly believe, however, and have the best possible grounds for saying so, that not only will that loss as time goes on become a decreasing quantity, but that the business which will be brought to the Post Office in other branches will be so satisfactory as to entirely justify the departure in every way. Further than this, the movement is to be highly commended on Imperial grounds. It will promote and extend the spirit of British kinship and intercommunication of thought and of trade in a manner which many at this time little dream of, and therefore from every point of view our Postmaster-General is to be congratulated.

We cannot leave the subject without pointing out, as it is our duty to do, what the general press of the country has not recognised, not being aware of the facts; and that is that the Postal Reform Committee, so ably presided over by Sir Hugh Gilzean-Reid, and prominent among the members of which have been Mr. C. Arthur Pearson, Mr. Upcott Gill, and Mr. Theo. Feilden, has had no small hand in bringing about this reform, and the Postmaster-General has in this connection practically adopted the views in certain important particulars advanced by the Committee. At a meeting of these gentlemen on the 24th inst., it was decided, whilst fully appreciating the concession made, to proceed along the lines of progress, and to make the Committee of a permanent character in order to advance by every possible means the movement in favour of securing better postal rates for periodicals between the Mother Country and the other Colonies and Dependencies of the British Empire on similar lines to those arranged between Great Britain and Canada; further, to suggest additional facilities in regard to Canada.

En passant, it is a curious commentary that now, whilst THE ELECTRICAL MAGAZINE and other such journals weighing under and up to 1lb. can be sent to Canada at a charge of one penny, it costs threepence to send such a publication to any part of the United Kingdom. This is a matter for further agitation at the earliest opportune moment. Meantime it is well to have got something, and the day that sees the consummation of the all-round reforms which the Committee aims at will mark an epoch in the Imperial and trade advancement of the British Empire.

Turkish Trade.

MR. GEORGE THOMAS, the Honorary Secretary of the Chamber of Commerce for Turkey (North of England), advises us that in view of the probable extension in the near future of the electrical industry in Turkey his directors are of opinion that contractors and engineering establishments in England should take some steps to place themselves in a position to be able to tender when necessary.

At the same time we are reminded that a special permit from the Turkish Government is necessary before a dynamo can be imported into the country, but the number of electrical installations in Turkey is steadily increasing and the Government contemplate lighting the capital and other cities with electricity and supplying electric traction for the tramways.

It has been suggested that contractors and electrical firms in England should appoint agents in Constantinople and be prepared to send experts to Turkey whenever necessary in the same way as the Belgians, Germans, and others do. So far Germany has obtained most of the electrical enterprises there, but it is hoped that if English firms will show a little activity and energy, they will be able to secure a fair amount of business when the occasion presents itself, especially as the Ottoman Government has recently shown a tendency to favour British enterprises.

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The National Electrical Manufacturers' Association.

THE second annual meeting of this association was held in London on the 9th inst. The greater part of the meeting was devoted to a discussion as to when and where the next electrical exhibition should be held. The Corporations of Manchester and Salford are strongly urging that an electrical exhibition be held in their district, and offer substantial guarantees therefor. But it was decided by a majority of one that no exhibition should be held until 1909 as against next year, the resolution being:

> "That we should obtain some tangible plan of what could and should be done in 1909; and that the secretary be instructed to carry on the negotiations with the Corporation of Manchester, &c., in order to ascertain what financial guarantees were forthcoming in order to warrant the holding of an exhibition in Manchester."

POWER: and its application to INDUSTRY

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Power, its Generation, Transmission, and Distribution.

Electric Pumping for Docks.

The Application of Electricity to the Driving of Pumping Machinery for Pontoon and Graving Docks.[*]

W. C. MOUNTAIN.

THE driving of the pumping machinery in graving and pontoon docks is a use to which electricity can be applied with the greatest advantage. The author does not recommend putting down an electrical generating plant for driving the pumping machinery on a single or probably even on two docks, but where owners possess a number of docks there is no doubt that one central station which can supply current to the whole of them would be found very much more economical than having independent steam pumping stations with a staff of men at each dock. The same remarks apply to the driving of the pumping machinery on pontoon docks. These are specially suitable for electric driving, as it is either necessary to have the steam machinery in a very cramped position or to convey steam from the shore through flexible pipes.

The whole question becomes one of cost, and the object of this paper was to bring forward some actual examples of docks driven both by steam and by electricity, giving the principal data as regards dimensions, pumping machinery, and the cost of pumping per ton docked.

The schedule, Table 1, gives particulars of the docks described (in a condensed form) and Table 2 gives information of electrical installations in floating docks, which details were kindly supplied to the author by Messrs. Clark & Stanfield, who are the designers of the docks in question.

The author gave more detailed descriptions of each dock, some of which are as follows: Two pontoon docks, owned by Messrs. Smith's Dock Company, North Shields, were described, the larger one being electrically driven, and the smaller one steam driven.

The particulars of the electric pontoon are:

Capacity of dock in tons		6400
Size of dock: Length in feet		435
Width in feet		66
Draught in feet on sill when pontoon is sunk		21½
Tons of water to empty		8500
Head in feet, maximum		22
Type of pumps		Vertical centrifugal
Number of pumps		8
Diameter of discharge pipe in inches		18
Capacity in gallons per minute		7930
Number of motors		8
Horse-power of each		60
Cost of upkeep		Very slight
Source of supply		Own plant—two 200kw. d.c. dynamos.
Voltage		460
Consumption in B.T.U.'s to empty		276
Price of current per unit		1d.
Cost per lift		23s.
Time to empty in minutes		40
Number of men attending motors		2
Wages per man per week		36s.
Number of vessels docked per year		144
Gross tonnage docked per year		502,533
Approximate value of pumping plant		£3798
Cost per ton docked: Power	.079d.	
Interest and depreciation at 10 per cent. per annum	.182d.	
Wages	.089d.	
		.350d.

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[*] Abstract of paper read before the North-East Coast Institution of Engineers and Shipbuilders, March 1st, 1907.

The eight electrical motors are of the vertical spindle type, each capable of developing 60e.h.p. when running at a speed of 385r.p.m., with 460 volts at the terminals. These motors have run for about six and a half years with very low cost of upkeep.

The weight of the armature is supported on a ball-bearing, carried by the bedplate of the motor, and the upper end of the spindle runs in a bush. At the bottom of the

TABLE 1.—DETAILS OF DOCK PUMPING.

Name of dock	Aberdeen	Austin & Son Wear Dock	Blyth No. 1	Blyth No. 2	Havana
Power used for pumping	electric	electric	electric		electric
Capacity of dock (tons)	425	2600*	..		10,000
Size of dock: Length (feet)	126	400	377	320	530
Width	37	51	55	55	72
Draught on sill	15	18' 9"	..		..
Tons of water to empty	632	3875	12,000	7000	14,800
Head: Maximum	15' 10"	27'	30'		..
Average	10' 6½"	16'	..		25.5
Pumps: Type	vert. centr.	horiz. centr.	horiz. centr.		Invincible vert. centr.
Number	2	4	2		10
Diameter of discharge pipe	12"	18"	48" impeller		12"
Capacity (gallons per minute each)	3990	..	8400		..
Motors: Number	2	4	2		10
Horse-power each	16.2	70	105		30
Cost of upkeep	£2 per year	£20 per year	very slight		..
Current: Source	town supply	town supply	town supply		gen. on pont.
Voltage	220d.c.	220d.c.	460d.c.		400d.c.
Consumption (B.T.U. to empty)	13	123	460	312	620
Price per unit	3d.	1⅜d.	1¼d. less 5%		..
Cost per lift	3/3	13/9	45/7	35/2	..
Time to empty (minutes)	35	25	120		150
Men: Number	2	1	1		..
Wages each per week	at 50/- & 36/-	34/-	28/-		..
Number of vessels docked per year	324	83	75		..
Gross tonnage docked per year	50,000	211,000	183,000	124,000	..
Approximate value of pumping plant	£1060	£1400	£1700		£4500
Cost per ton docked: Power	.252d.	.064	.224	.255	..
Interest and depreciation (10%)	.51d.	.159	.133		..
Wages	.95d.	.100	.056		..
Total cost per ton docked (pence)	1.712d.	.323	.413	.444	

* This dock will hold vessels up to 3600; this 2600 ship is taken as an example only.

Name of dock	Smith's Docks.		R. Stevenson	Wear Comm.
	West Pontoon	East Pontoon	Hebburn	No. 1. Grav. dk.
Power used for pumping	electric	steam	steam	gas
Capacity of dock (tons)	6400	3200	..	1760 (av.)
Size of dock: Length (feet)	435	335	700	..
Width	66	50	90	..
Draught on sill	21½	20½	29	17' 6"
Tons of water to empty	8500	5170	63,200 56,000 at 26' draught	10,632
Head: Maximum	22	20	39' 8"	..
Average	..	..	20"	..
Pumps: Type	vert. centr.	Clark & Stansfield horiz. centr.	Tangye horiz. centr.	Tangye horiz. centr.
Number	8	4	2	2
Diameter of discharge pipe	18"	22"	45" 72" impell.	21"
Capacity (gallons per minute each)	7930	7240	80,000	9320
Motors: Number	8	..	2 engines	2 Tangye
Horse-power each	60	..	vert. comp.	gas engines
Cost of upkeep	very slight	..	direct-coupled	of 40h.p.
Current: Source	2-200kw. sets	2 mar. boilers	13½" & 27"	each
Voltage	460d.c.	..	20"	..
Consumption (B.T.U. to empty)	276	..	350i.h.p. each	..
Price per unit	1d.	..	..	..
Cost per lift	23/-	..	26/3	gas, 7/10
Time to empty (minutes)	40	30	150	.
Men: Number	2	4	2	1½=3 for 2 dks.
Wages each per week	36/-	3 at 30/-, 1 at 18/-	36/-	36/-
Number of vessels docked per year	144	96	60	46=40 pumpings
Gross tonnage docked per year	502,533	239,719	189,896	81,688
Approximate value of pumping plant	£3798	£2000	£7000	£2000
Cost per ton docked: Power	.079	.222	.099	.046
Interest and depreciation (10%)	.182	.201	.885	.587
Wages	.089	.282	.114	.412
Total cost per ton docked (pence)	.350	.705	1.098	1.045

TABLE 2.—ELECTRICAL INSTALLATIONS IN FLOATING DOCKS.

Dock.	Lifting Power in tons.	Date.	Tons water removed (max. ship).	Mean head in feet, including loss by friction in pipes.	Diameter of pump.	No. of Sets.	Electrical Equipment (averages).						Contract time of lift.
							E.H.P. of Motor.	Volts.	Nominal Amps.	Actual Amps.	Revs. min.	Price B. of T. Unit.	
North Shields No. 2	6,500	1896	..	..	18	8	60	..	..	..	385	..	30m.
Havana	10,000	1897	14,800	25.5	12	10	30*	400	62	62	600	..	2½h.
Grimsby ..	425	1900	720	14.6	12	2	20*	300	67	60	530	..	30m.
Aberdeen ..	425	1900	750	14.0	12	2	20*	220	..	75	530	3d.	30m.
Sunderland ..	3,600	1902	5,100	18.3	18	4	70†	..	..	..	..	1½d.	1h.
Great Lakes ..	4,000	1904	7,400	15.3	13	6	36	..	..	..	..	..	2h.
Port Said ..	3,000	1904	5,600	19.5	15	2	64	440	108	95	..	10d.	3h.
Haslar	500 (1,000)	1905	1,600	11.6	14	2	32	220	108	98	..	..	1h.

* B.H.P. † Approximate.

motor-shaft there is the flexible coupling which drives the vertical pump-shaft. The weight of the vertical shaft is also carried by a cast-iron deck-plate containing a ball-bearing, so that all the weight is taken off the spindle of the centrifugal pump. The intermediate bearings are fitted with gun-metal brasses.

The pumps are of the vertical spindle type with the delivery branches placed horizontally, the water being brought in through a single inlet at the bottom of the pump to a single sided impeller. The valves for controlling the pump are worked from a deck-house, and the switching and starting gear in connection with the motors is also worked from the upper platform.

As a comparison between the electric and steam-driven pontoon the following figures of the steam-driven pontoon are of interest. It will be noted that it is smaller than the electric pontoon, which would, to some extent, account for the higher cost of docking.

Power used for pumping	Steam
Capacity of dock in tons	3200
Size of dock: Length in feet	335
Width in feet	50
Draught in feet on sill when pontoon is sunk ..	20½
Tons of water to empty	5170
Maximum head in feet	20
Type of pump	Horizontal centrifugal
Number of pumps	4
Diameter of discharge pipe in inches	22
Capacity in gallons per minute	7240
Number of boilers ashore	2
Time to empty in minutes	30
Men required for attending to pumps and proportion for stoking	4
Total wages per week, say	108s.
Number of vessels docked per year	96
Gross tonnage docked per year	239,719
Approximate value of pumping plant (estimated) ..	£2000
Cost per ton docked: Power	.222d.
Interest and depreciation at 10 per cent. per annum	.201d.
Wages	.282d.
	.705d.

As of interest, the author compared the cost of pumping a large pontoon dock with that of pumping a smaller dock, having been fortunate in getting from Mr. Nichol, the engineer to the Aberdeen Harbour Commission, very full data of the working of his electrically driven pontoon dock over a period of several years.

The dimensions are as under:

Power used for pumping	Electricity
Capacity of dock in tons	425
Size of dock: Length in feet	126
Width in feet	37
Draught in feet on sill when pontoon is sunk ..	15
Tons of water to empty	632
Maximum head	15ft. 10in.
Average head	10ft. 6½in.
Type of pumps	Vertical centrifugal
Number of pumps	2
Diameter of discharge pipes in inches	12
Capacity of each pump in gallons per minute	3990
Number of motors	2
Horse-power of each	20 to 25
Actual horse-power required	16 2
Cost of upkeep per annum	£2
Source of current	Town supply
Voltage (direct current)	220
Consumption in B.T.U.'s to empty	13
Price per unit	3d.
Cost per lift	3s. 3d.
Time to empty in minutes	35
Number of men on dock	2
Wages per week for two men	£3 16s.
Number of vessels docked per year	324
Gross tonnage docked per year	50,000
Approximate value of pumping plant	£1060
Cost per ton docked: Power	.252d.
Interest and depreciation at 10 per cent. per annum	.51d.
Wages	.95d.
	1.712d.

The type of electric motor used on this dock is exactly similar to the motors on Messrs. Smith's Dock Company's dock, with the exception that in the case of Messrs. Smith's the motors are 60h.p. and in the present case 20h.p. to 25h.p.

The method of attachment of the pumps, vertical shaft, and other details are also similar.

The electrically-driven Havana dock was built by Messrs. Swan & Hunter for the Spanish Government, Messrs. Clark & Stanfield being the consulting engineers, and the author's firm supplying the electrical machinery.

It was found impossible to get details as to the cost of working, but the following general information was available:

Lifting power in tons	10,000
Power used for pumping	Electric
Size of dock: Length in feet	530
Width in feet	72
Tons of water to empty	14,800
Mean head in feet, including loss by friction in pipes	25.5
Type of pump	Vertical centrifugal
Number of pumps	10
Diameter of discharge pipe in inches	12
Motors: number	10
Horse-power of each	30
Voltage	400
Current	Direct
Source	Generated on pontoon
Consumption in B.T.U.'s to empty	620
Time to empty in minutes	150

As this dock was designed to work off shore, the electrical power required for driving the pumps was generated on the dock itself, and consisted of:

Two locomotive boilers, each for 150lb. working pressure.

Two combined engines and dynamos, the engines having cylinders 13½in. and 23in. by 12in., running at 350r.p.m, and coupled to dynamos of 125kw. capacity. There were five motors on each side of the dock, and these were controlled from a central switch-house. The electric motors used in this dock were precisely similar in design to those supplied for Smith's, and for Aberdeen; ball bearings were used for carrying the weight of the armature and the vertical shaft.

The power was transmitted from the motors to the pumps by vertical shafts, and the pumps were of the vertical spindle type, but with double inlets, so that the water was brought to both sides of the impellers; this construction being considered by Messrs. J. & H. Gwynne (who built the pumps) as preferable to the single-inlet construction, as it avoided all end thrust, and the pump was considered more efficient.

The author having so far dealt exclusively with pontoon docks, mentioned that electricity can be quite as economically applied to the driving of pumps on graving docks, and gave examples.

The Blyth Shipbuilding Company were fortunate in being able to obtain a supply of current from the Northern Electric Supply Company from their Blyth station, and they decided to utilise this current for driving the machinery in connection with the two docks. This dock was originally driven by two steam engines driving the main pumps, and two small engines driving the drainage pumps, and the problem which had to be faced was to supply motors which could fit on to the foundations of the steam engines and enable the change over to be made in the shortest possible time.

The author therefore designed two special multipolar motors which were built to fit into the space between the two existing centrifugal pumps. Each motor is entirely self-contained—that is, the shafts run in their own bearings, so that either motor could work independently of the other, each motor normally being of 105e.h.p. when running at a speed of 250r.p.m. The motors in connection with the drainage pumps were of 40h.p. and 13h.p. respectively. The actual change over from steam to electricity was carried out over a week-end, so that the Blyth Shipbuilding Company's docking arrangements were in no way interfered with.

The general particulars of these docks are as follow:

	No. 1.	No. 2.
Power used for pumping	Electric	Electric
Size of dock: Length in feet	377	320
Width in feet	55	55
Tons of water to empty	12,000	7000
Maximum head in feet	30	30
Pumps: Type	Horizontal centrifuga	
Number of pumps	2	
Diameter of impellers in inches	48	
Diameter of discharge pipe in inches	20	
Gallons per minute, each	8400	
Number of motors	2	
Horse-power of each	105	
Cost of upkeep	Very slight	
Current: Source	Town supply	
Voltage (direct current)	460	
Consumption in B.T.U.'s to empty	460	312
Price per unit	1½d. less 5%	
Cost per lift	45s. 7d.	35s. 2d.
Time to empty in minutes	120	120
Men: Number	1	
Salary	28s.	
Number of vessels docked per year	75	
Gross tonnage docked per year	183,000	124,000
Approximate value of pumping plant	£1700	
Cost per ton docked: Power	.224d.	.255d.
Interest and depreciation at 10 per cent.	.133d.	
Wages	.056d.	
Total cost per ton docked	.413d.	.444d.

This installation has been running for several years without a hitch of any kind, and is a practical example of how an existing dock, with its steam machinery, can be converted into an electrically-driven dock at a very small expense, and with very satisfactory results from a working standpoint.

From figures supplied by the Blyth Shipbuilding Company to the author, he ascertained that under the old steam-pumping the cost for coal, stores, wages and water for boilers, for emptying the dock about twenty times, was £169 9s. 7d. With the electrical plant, for emptying the dock nineteen times, the cost was £99 9s. This shows a very considerable saving.

By the courtesy of Messrs. Robert Stephenson & Co., the author was able to show illustrations of their new dock at Hebburn, which is steam-driven; and they also supplied data as follows:

ower used for pumping		Steam
Size of dock: Length in feet		700
Width in feet		90
Draught in feet on sill at ordinary spring tides		29
Tons of water to empty at this draught		63,200
Tons of water to empty at 26ft. draught		56,000
Maximum head		39ft. 8in.
Average head		20ft. 0in.
Pumps: Type		Tangye horizontal centrifugal
Number		2
Diameter of impellers in inches		72
Diameter of delivery branch in inches		45
Capacity in gallons per minute		80,000
Engines: Number		2
Type		Vertical compound direct-coupled
Diameter of cylinders in inches		13½ & 27
Length of stroke in inches		20
Indicated horse-power of each		350
Men: Number		2
Wages per week per man		36s.
Total wages per week		72s.
Number of vessels docked per year		60
Gross tonnage docked per year		189,896
Approximate value of pumping plant		£7000
Cost per ton docked: Power	.099d.	
Interest and depreciation at 10 per cent. per annum	.885d.	
Wages	.114d.	
		1.098d.

By the courtesy of Mr. H. H. Wake, the engineer of the River Wear Commission, the author gave the following figures respecting the pumping machinery fitted to No. 1 Graving Dock, and expressed the belief that the credit of introducing gas-engine driving for this purpose is entirely due to Mr. Wake. It is interesting to see how very economical this system of pumping is.

Power used for pumping		Gas
Size of average vessel docked, in tons		1760
Draught on sill		17ft. 6in.
Tons of water to empty		10,632
Pumps: Type		Tangye horizontal centrifugal
Number		2
Diameter of discharge pipe in inches		21
Capacity in gallons per minute		9320
Engines		Tangye gas engines
Number		2
Horse-power of each		40
Cost per lift for gas		7s. 10d.
Men: Number for two docks		3
Wages per week for each man		36s.
Gross tonnage docked per year		81,688
Approximate cost of pumping plant		£2000
Cost per ton docked: Power	.046d.	
Interest and depreciation at 10 per cent. per annum	.587d.	
Wages	.412d.	
		1.045d.

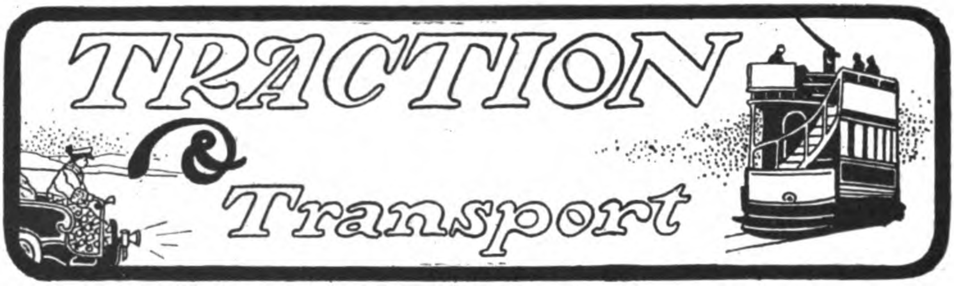
A gas engine applied in this way has many of the advantages of an electric motor, as it can be started and stopped at any time, and it is not necessary to keep up steam in boilers.

The author exhibited drawings of several types of centrifugal electric pumping sets. One, by Messrs. Drysdale & Co., showed a standard design of horizontal spindle-motor coupled to centrifugal pump. The pump illustrated has a discharge 24in. in diameter, and is capable of delivering 13,500 gallons of water per minute; the makers state that the overall efficiency of the pump and motor is about 70 per cent. This efficiency, of course, would depend, to a certain extent, upon the head, but there is no doubt that for moving large quantities of water the combination of a centrifugal pump and electric motor leaves very little to be desired both as regards space occupied and small first cost.

Another illustration represented a large vertical-spindle centrifugal pump and motor, the motor being suspended by wire ropes, and although the particular pump was supplied by the author's firm for the unwatering of collieries, a similar arrangement might be very conveniently used for the unwatering of graving docks during construction. The motor is of the totally enclosed type and the water from the centrifugal pump (which is placed underneath) passes through the motor casing and keeps the motor cool. It further makes a very balanced arrangement, as there are no overhanging pipes, and the water is finally delivered to a breeches pipe on the top of the pump, on which the rising main or delivery pipe is mounted.

The author also showed a vertical-spindle three-phase motor as supplied by his firm for the driving of centrifugal pumps for a graving dock in Spain. The motors were placed in a room on the surface and vertical shafts taken to the pumps, which were placed at the dock bottom. This is a very convenient arrangement and one which will probably be adopted for new docks in the future.

The author concluded by indicating that the figures brought forward go to show that electricity can be applied very economically for the driving of pumping machinery on both pontoon and graving docks, and expressing his thanks to Mr. B. F. Crosfield, for assistance in the preparation of the paper and the tables.



TRACTION & Transport

A classified list of Traction and Transport articles will be found in the World's Electrical Literature section.

The Dumbarton Electric Tramways.

The inauguration of the new electric tramway system at Dumbarton took place on February 20th. These tramways have been laid down and equipped throughout by Messrs. Crompton & Co., of London and Chelmsford, for the Electric Supply Corporation, who hold powers for running them under the Light Railways Act. The construction of the tramways was authorized by the Dumbarton Tramways Order of 1904 and the Dumbarton Tramways Confirmation Act, also of 1904.

The system serves the principal streets of the town, and consists of two sections—one running from the eastern boundary in the Glasgow Road through the town to the north-western boundary in the Alexandria Road, and the other section joining the first at Church Place, and running thence to the boundary near the old toll-house on Bonhill Road.

The track is principally single-line with turnouts, but double-line in some sections of the principal streets. The track rails are of manganese steel, and weigh 90lb. to the yard. They have grooves 1⅛in. wide, and are laid to a gauge of 4ft. 7¾in. They are bonded throughout with "Neptune" bonds, and cross-bonded at every 40yd. The rails are laid on concrete foundations, and the roadway is finished with Whinstone sets with pitch grouting. The points and crossovers are of cast steel supplied by Messrs. Hadfields, of Sheffield. The track passes under two railway bridges, and in each case it was necessary to lower the roadway in order to obtain sufficient head-room for the cars. A new steel girder bridge has had to be erected to carry the track across Gruggies Burn.

Power is supplied to the cars from two overhead trolley wires, supported in most cases by bracket arms, and in a few cases by span wires. The trolley wire is 2/0 section and grooved. The steel tubular poles are set direct in the ground without the usual cast-iron or other protecting bases. The overhead system is fed from three feeder pillars connected to a trunk main on the power station.

The B.M.R. system of signalling is provided at the Bridge Street and Strathleven Place sections of the line to assist in the control of the traffic. In each section there are three signal lamps to allow of three cars going in the same direction at one time.

At the present time there are six cars in service. These are four-wheel cars with radial trucks, each car seating fifty-six passengers, and being provided with a cover over the top seats. Each car is equipped with two 30b.h.p. motors and controllers of the Westinghouse type.

The gauge of the system and the general design of the cars have been arranged to correspond with those of the Glasgow tramways, it being intended at an early date to connect this tramway system with that of Glasgow through the Dumbarton County Tramways, for which powers have now been obtained.

The power station is designed for supplying current for lighting and motive-power purposes in the town, as well as for the tramways, the generators being so designed that they can be used for either service. The main generators include three direct-coupled sets, two having an output of 185kw. and one of 50kw. The engines in each case are by Messrs. Belliss & Morcom, Ltd., of their compound, two-crank, enclosed type. The larger engines each develop 270b.h.p. at a speed of 420 r.p.m., and the smaller one 75b.h.p., running at a speed of 575r.p.m. The steam pressure is 180lb. per square inch, and the engines exhaust to the atmosphere.

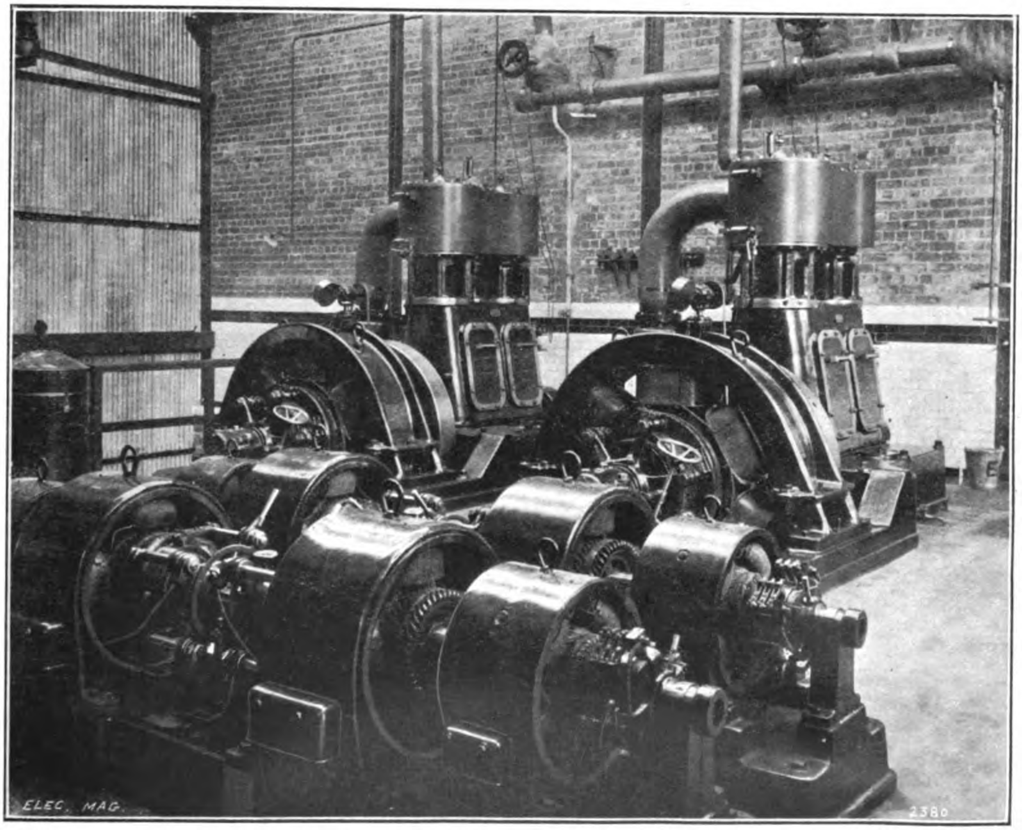


FIG. 1. THE DUMBARTON ELECTRIC POWER GENERATING PLANT.

Each engine is coupled direct to a multipolar open-type dynamo, made by Messrs. Crompton & Co., and wound so as to give any pressure between 480 volts and 550 volts, so as to be serviceable either for the public electricity supply system or the traction feeders.

An important feature of this station is the use of storage batteries and automatic reversible boosters for regulating the load on the generators and the pressure on the bus bars. These boosters work on the "Crompton-Mackintosh" system, and enable the battery to provide automatically for the fluctuations in the load, keeping the load on the generators constant throughout the day.

There are two separate switchboards, one for the lighting section, and the other for the traction. The generators are connected to panels on the lighting board, and from there can be connected either to the lighting bus bars or the traction board. The whole of the circuit-breakers on both boards are of Messrs. Crompton & Co.'s "C.B.H." type. They operate with overload or reverse currents in the case of the generators, and overload only for the feeders. The circuit-breakers are of the free-handle type, thus avoiding the necessity of having switches in series with the circuit-breakers.

The connections between the dynamos, feeders, and switchboards, and all the regulating resistances are fixed in a chamber under the switchboard gallery, and are entirely fireproof, bare copper secured to porcelain insulators being used throughout.

Another three-wire storage battery is provided for use in conjunction with the lighting system, and two balancer booster sets are provided for enabling these lighting batteries to be charged and discharged without the use of regulating cells, and also to compensate for the inequalities of load on the two sides of the system, the balancing machines being powerful enough to drive the boosters at their normal rated output, in addition to supplying an out-of-balance current of 30amps.

In the power house are two water-tube boilers by Messrs. Babcock & Wilcox, each capable of evaporating 6000lb. of water per hour, and provided with superheaters for raising the temperature of the steam by 120deg. F. They are fitted with chain-grate stokers supplied by Messrs. Bennis & Co., and driven by a 2h.p. "Crompton" motor. Water is supplied to the boilers through a "Worthington" feed-heater by three electrically-driven pumps. These are of the double-acting plunger type connected through self-contained worm gears to "Crompton" enclosed-type motors. The through efficiency of these pumps is over 60 per cent., the steam consumption per pump horse-power being considerably less than would be the case with steam-driven pumps. A general view of these pumping sets is given in Fig. 2.

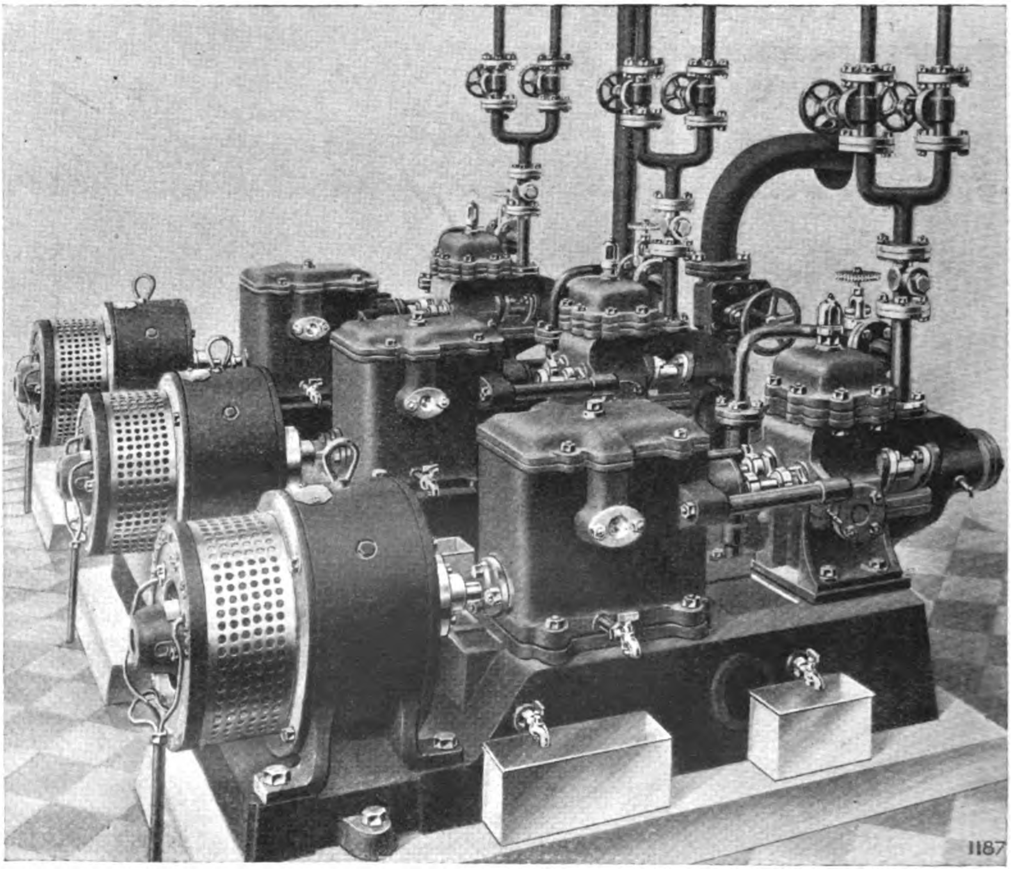


FIG. 2. ELECTRIC FEED PUMPS; DUMBARTON ELECTRIC POWER STATION.

Adjoining the power house is a car-shed which will accommodate nine cars, and a repair shop fitted with all tools necessary to carry out running repairs. Pits are provided between the rails for giving access to the motors for cleaning, inspection, and overhauling.

Central Station Practice

The World's Electrical Literature Section contains a classified list of all articles of interest to Central Station men. CONSULT IT and save yourself much valuable time.

*Tests of a Producer Gas Engine.**

G. W. BISSELL.

THE writer presents briefly in this paper the principal and most interesting results of tests of a producer gas engine installed for electric-light service in a small town in Iowa.

It was a three-cylinder vertical single-acting engine rated at 150b.h.p. and guaranteed to develop one-half its power and not to exceed 1.5lb. anthracite pea coal per b.h.p. hour; the cylinders were 15in. × 18in., and the speed 250r.p.m.

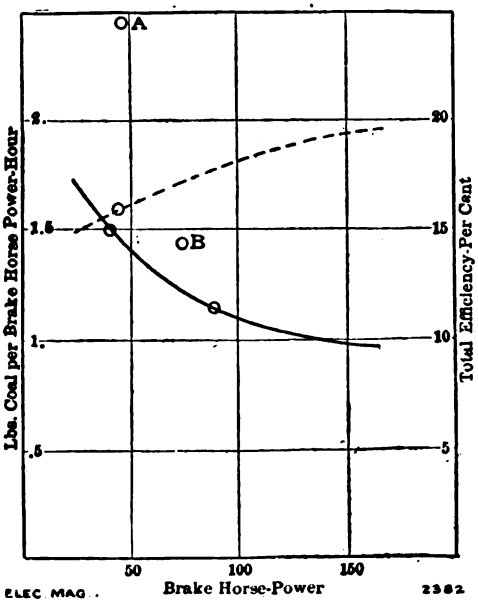


FIG. 1. ECONOMY AND EFFICIENCY CURVES.

The producer was of the suction type and was furnished with vaporizer, scrubber, &c. The engine was started by compressed air supplied from storage tanks filled by a small gasolene engine which served also to run a small fan-blower for starting the producer and to elevate coal to the storage hopper.

The engine was belted to a 75kw. two-phase Westinghouse generator and exciter. For purposes of brake-tests the belt was thrown off and a prony brake applied to a special brake pully loaned and placed by the makers. All usual and necessary precautions were taken in securing the data.

The results of the brake-tests were as follows:

Date.	Run.	Duration, hours.	Average b.h.p.	Per cent. of Rating.	Coal as Fired per b.h.p.-hr.	Total efficiency from Coal.
March 1, 1906	I	6	40.1	26.8	1.51	15.69
March 2, 1906	II	7	82.5	55.0	1.15	17.56
March 3, 1906	III	6	156.9	104.2	0.99	19.69

The results of the plant tests were as follows:

Date.	Run.	Duration, hours.	Total kw. hrs.	Average kw.	Estimated b.h.p.	Coal per kw.-hr.	Estimated coal per b.h.p.-hr.	Cost of coal per kw.-hr. at $6.
March 15, 16, 1906	*A*	14.08	408.6	29.02	48.6	4.10	2.45	$.0123
March 16, 17, 1906	*B*	12.50	589.3	47.14	74.0	2.23	1.43	.0067

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* Read before the American Association for the Advancement of Science, New York, abstracted from *Power*.

Fig. 2 shows the load curves for the two plant tests. Curve *A* is for the ordinary lighting load. Curve *B* is for the lighting load plus an electrically-driven air-compressor used for pumping by air-lift, and represents normal plant conditions.

Fig. 1 shows the economy and efficiency curve for the brake-load tests, and *A* and *B* thereon are from "estimated coal per brake h.p.-hour" in the plant tests.

The heat balance for run III of the brake-load tests is given below.

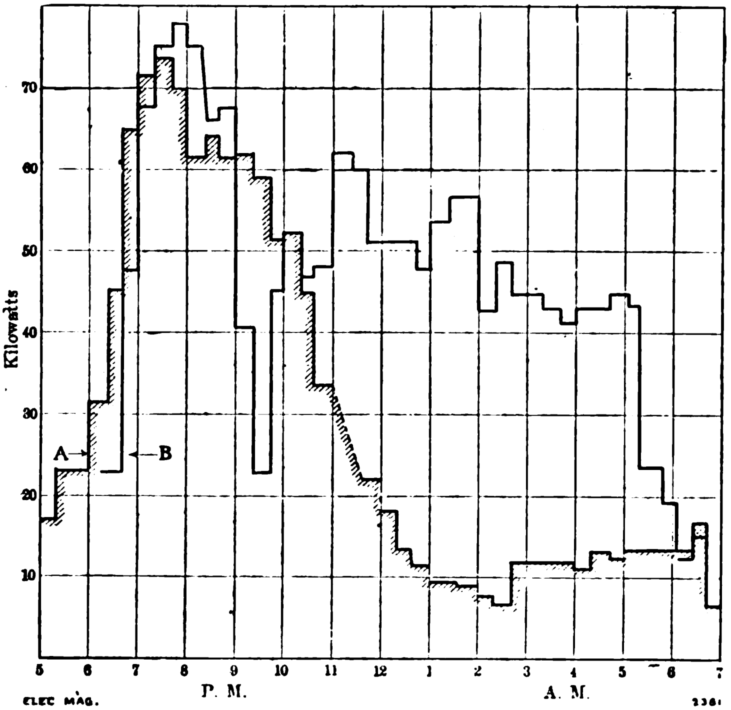


FIG. 2. LOAD CURVES FOR ENGINE TESTS.

HEAT BALANCE AT FULL LOAD.

B.t.u. in coal as fired	—	100%	12,143,500
,, in b.h.p.	2,391,524	19.69	
,, in unburned coal in ash	1,382,000	11.46	
,, in radiation from producer	285,000	2.33	
,, in radiation from scrubber	39,000	0.31	
,, in vaporizer	79,000	0.65	
,, in scrubber water ..	887,000	7.15	
,, in jacket water	2,539,000	20.9	
,, in exhaust gases ..	3,856,000	5.55	
,, unaccounted for ..	674,976	5.55	
	12,143,500	100.00	12,143,500

* * *

Central Station Supply Economics.

Their Study, and what it promises in the way of Cheaper Supply.

A. M. TAYLOR.

(Continued from THE ELECTRICAL MAGAZINE, February, page 81.)

WE have now sufficiently indicated a method of obtaining the relation existing between "running" and "standing" charges in the more important items of coal, petty stores, wages, and repairs; and the way in which the combined charges are made up for a given station for lighting, power, and traction; whether the units sold in all three cases are equal, or whether they are in proportion to the load factors of the several loads. Let us now endeavour to apply these results to the more complicated case where the numbers of units supplied for lighting, power, and traction bear no relation whatever to one another.

Apportionment of Total Charge to Lighting, Power, and Traction.

We will assume that, in the case of the station whose charges it is desirable to investigate, the approximate running cost has already been obtained, in the manner indicated for each successive item comprising the *combined* expenses.

We will assume also that the combined operating expense of the station is known and the combined charges to be made per unit to provide for all items of expense. What we desire to know is, how to proportion the charge per unit among the three classes of load, lighting, power, and traction.

For simplicity's sake let us take the figures already arrived at for running costs (multiplying by 1.25 to reduce to per unit sold), viz.:—

Coal = 0.16d. × 1.25 = 0.20d.; petty stores = 0.02d.; wages = 0.04d.; repairs = 0.033d.; sundries = 0.023d. Total = 0.316d. per unit sold.

As an example let us apply these figures—though, as already stated, they are too high for a station of this size—to the Liverpool costs for 1904. The number of units sold for lighting, power, and traction were approximately 8,300,000, 2,054,000, and 19,000,000; total 29.350,000, approximately.

The revenue obtained was £229,677, or an average figure over all three classes of the supply of 1.88d. per unit.

Let x, y, z be the three rates (for the standing charges) required to be obtained. First deduct from the 1.88d. the sum of the running charges (1.88d. − 0.316d. = 1.564d.), and we have:—

Lighting:
8,300,000 units at xd. = £ a (?)
Power:
2,054,000 „ at yd. = £ b (?)
Traction:
19,000,000 „ at zd. = £ c (?)

Total combined:
29,354,000 units at 1.564d. = £191,000

From the above we can easily deduce the rates (standing charges) x, y, and z, bearing in mind that they are in the inverse ratios of the load factors 12½, 25, and 30 per cent; hence the quantities composing the total of the standing charges (£191,000) are obtained.

These rates will be found to be respectively 2.71d., 1.36d., and 1.09d. per unit sold, to which must in each case be added the running cost = 0.316d., making respectively 3.02d., 1.67d., and 1.40d. per unit sold for the combined charge.

It may be said, as against the acceptance of these figures, that the load factors for power and traction have been taken too low, and that 30 per cent. and 40 per cent. are nearer the mark. The effect of taking these latter values would be to give the following values to x, y, and z, viz., 3.04d., 1.26d., and 0.95d., to which, adding 0.316d. as before, we get 3.35d., 1.57d., and 1.26d. per unit sold for the combined "running" and "standing" charges for the lighting, power, and traction loads respectively. It is interesting to note that the price charged for traction at Liverpool during the year in question was 1.16d., which is in fair agreement with the 1.26d., bearing in mind that the latter figure includes a share of office expenses which, of course, were not incurred, and that the running costs, as already explained, are purposely taken too high. The interest charges on traction and lighting cables, &c., would, of course, also have to be distinguished and properly debited to get the true traction charge.

What the author wishes, however, specially to emphasize is the large standing charge debitable to the power load, viz., 1.26d., on the most favourable basis and assuming values for the "running charge," which would certainly be lowered in a large station like Liverpool, at the expense of an increase in the "standing charge."

The author also wishes to call the attention of central station engineers to the enormous possibilities of development opening to them if these "standing charges" can in any way be cancelled or reduced, and if it be conceded that the "running charges" are as low as he has put them.

The attached table (see page 80 of first part of article) worked out some time ago on the basis of deducting the whole of the coal charges and calling everything else "standing charges" (a procedure not so far wrong as regards proportion as might appear), is given in the hope of eliciting further discussion, though it is avowedly only a first approximation.

Internal Diversity Factor—an Overrated Asset.

Many electrical engineers have seen, in what we may call the "internal diversity factor" of the motor load, the supposed key to the problem of cheap supply; imagining that the charge per unit as determined at the station would have to be divided by the diversity factor before the charge to the consumer would be arrived at, for the reason that the "standing charge" per annum per kilowatt of consumer's plant is undoubtedly less than that per kilowatt of maximum demand (at the station) in that proportion.

As the author of the present paper made this same mistake in his paper on "Standby Charges" without it being challenged, it seems probable that it is very generally accepted. Indeed, the discussion on that paper showed clearly that there was this tendency. After careful consideration of this point, however, the author is convinced of the fallacy of the idea that the "internal" diversity factor of the motor load in any way reduces the charge per unit to be made to the consumer. On the contrary, it somewhat increases it.

Let it be clearly understood that we are speaking of the fluctuations of the loads of the individual motors, taken over short periods of time such as a quarter-hour or so. That is to say that, while A's motor is perhaps working at full load for the period considered, B's motor is running empty, with the result that the demand on the station during that period is only half that represented by the joint rated h.p. of the two motors, *i.e.*, the diversity factor is = 2.

The author is not referring to an inequality of the motor load "humps" (at the station) in the morning as against the afternoon, caused by diversity factor, which, so far as he has been able to ascertain, does not exist to any appreciable extent. This inequality was referred to by Mr. Wright in the discussion already alluded to, and no doubt where it exists in such a form that the afternoon "hump" is *less* than the morning "hump" it is entitled to consideration to the extent by which it removes the superposed motor load from the lighting "peak." But this case is only a mild form of a "restricted-hour" load, and as such can be dealt with on similar terms.

An example will probably make the above argument clearer, viz., that the charge per unit to the consumer is not reduced on account of "internal" diversity factor.

Take the case of four motors, each of 100 rated h.p., on the premises of four consumers, A, B, C, and D, and working intermittently at their full rated load for, say, 2¼ hours × 5½ days = 12⅜ hours per week (*i.e.*, 1235h.p. hours per motor per week out of a possible 16,800h.p. hours), or at a 7.35 per cent. load factor.

The maximum h.p. at the station (neglecting losses in transmission) is 100h.p., and the (limiting) diversity factor is, for this load factor, = 4.

Hence station load factor = 4 × 7.35 per cent. = 29.4 per cent.

In other words, we have 400h.p. connected up, and only 100h.p. demanded at the station.

For the sake of simplicity let us call this 100kw. at the station bus bars.

Then: Unit delivered to bus bars per annum—

$$= 100\text{kw.} \times 8760 \text{ hrs.} \times \frac{29.4}{100} = 254{,}000 \text{ units.}$$

Let the capital cost of the station, mains, and services be taken at £10,000 = £100 per kilowatt of maximum demand at station.

Then, taking interest and sinking fund and reserve fund at 7½ per cent. (0.075)—

Cost per unit

$$= \frac{£10{,}000 \times 0.075 \times 240}{254{,}000 \text{ units}} = 0.71\text{d. per unit.}$$

Interest, sinking fund, and reserve fund charge per kilowatt of maximum demand at

$$\text{station} = \frac{£750}{100}\text{kw.} = £7 \text{ 10s. per kilowatt.}$$

Other fixed charges assuming "total costs" = 1.0d. (after deduction of ¼ per unit for running charges = 0.75d.)—

$$= \frac{0.75 \times 254{,}000}{240 \times 100\text{kw.}} = \frac{£795}{100\text{kw.}}$$

= £7 19s. per kilowatt.

Total fixed charge at *station* = £7 10s. + £7 19s. = £15 9s. per kilowatt of maximum demand; or total fixed charge per *consumer's* kilowatt

$$= \frac{£(750 + 795)}{400\text{kw.}} = \frac{£1545}{400}$$

= £3 17s. per kilowatt.

Treating this charge on the maximum-demand principle, we get: £3 17s. per kilowatt of consumer, on 100kw., as equivalent to a daily charge per unit of—

$$\frac{925\text{d.}}{(12\tfrac{3}{8} \times 52\text{wks.})} = \frac{925}{643\text{hrs.}} = 1.46\text{d.}$$

Add: Running charge as above adopted ... ... = 0.25d.

Total ... ... = 1.71d.

But from the station point of view:

Total cost per unit at station (as ascertained earlier) = 0.71d. interest, &c., + 0.75d. other fixed charges + 0.25d. running charges = 1.71d.

Total revenue = 254,000 units at 1.71d. = £1810 per annum.

And from the consumer's point of view—

Units sold per consumer—
= 100kw. × 8760hrs. × $7\frac{1}{3}$ per cent. (L.F.)
= 63,500 units.

Revenue per consumer = 63,500 units at 1.71d. = £452 10s.

And: 4 consumers at £452 10s. = £1810 = the sum required to be raised annually.

Hence the price to be charged is the same per unit whether taken at the station or as made at consumer's premises, and diversity factor benefits nothing.

Summarizing, we have:

Cost per unit to consumer = 1.71d. (1.46 + 0.25).

Cost per unit at station = 1.71d. (0.71 + 0.75 + 0.25).

Hence it is *wrong* to divide the charge per unit obtaining at the station by the diversity factor in order to get the charge to be made to the consumer; and the assumption that consumer's charge varies inversely with diversity factor is an incorrect one.

In this is taken the very best case, for the consumer's L.F. considered, *i.e.*, neglecting "unrealised diversity factor."

Taking the same station costs, one might have added a fifth consumer, with the same result. The consumer's L.F. coming down to 5.89 per cent. The consumer's charge per kilowatt coming down to £3 2s. per kilowatt. The consumer's charge per unit remaining at $\frac{925 \times 0.8}{643 \times 0.8} = 1.46 + 0.25$ running charge $= 1.71$. The result coming out just the same as for the four consumers, though the diversity factor is 25 per cent. higher.

In the above example the consumer's load factor is only 7.35 per cent., and it has been assumed that a station load factor of 29.4 per cent. would be obtained with four such consumers, each accommodating one another, and the station, to the utmost conceivable extent (over an ordinary nine-hour day) resulting in a diversity factor of 4. This is the figure which the author suggested as the limit for a load having a $7\frac{1}{2}$ per cent. load factor in his paper on "Standby Charges," which, together with its corollary, that the average consumer's load factor × diversity factor = station load factor (in the limit), was severely criticised at the time, but has since been proved to be correct, having been checked by application to numerous stations throughout the country.

As a matter of fact, it is extremely unlikely that a diversity factor of 4, and hence station load factor of 29 per cent., would be obtained, owing to "unrealised diversity factor"; but, even if it were, the case worked out shows that it is better for low costs per unit to have a single 100h.p. consumer working continuously at 100h.p. during the working hours of an ordinary day than to have a number of consumers of poorer load factor, though giving a high diversity factor.

Combined Diversity Factor.

A treatment of the three classes of load absorbed at the station (lighting, power, and traction) in a similar way to the loads of three individual power consumers would show: (1) That the combined diversity factor at any moment is equal to the sum of the three maxima (at *whatever* hours they occur) divided by the maximum observed joint demand at that moment; and would probably show (2) that the average combined diversity factor, taken over a given cycle of, say, twenty-four hours, when multiplied by the average of the three load factors, will (in the limit) be equal to the resultant combined load factor, taken over the same period; also (3) that the average combined diversity factor is (in the limit) inversely proportional to the average load factor, *i.e.*, when the average load factor of the three loads is 30 per cent. the average combined diversity factor will be $3\frac{1}{3}$ (or less); when the L.F. is 20 per cent. the D.F. will be 5 (or less), and so on.

Diversity Improvement Factor.

The nearness with which the product of the average diversity factor and the average load factor agrees with the combined load factor might be called the "diversity improvement factor" of the station, and represents the extent to which the valleys in one class of load are filled by the peaks in the other two classes, and *vice versâ*. The object of the introduction of a restricted-hour system of charging is to improve this figure.

"Non-Interest-Paying" and "Ideal" Loads.

It will be generally conceded that if a load could be found for our generating stations which would at all times accommodate itself to the amount of spare capacity available in the generating stations and mains, it should not be chargeable with interest, &c., charges, unless it is proposed to make the new load bear part of the interest charges now borne by the existing light and traction loads.

A further consideration will, the author thinks, concede that the new load should not be debited with any standing charges that are now paid by the other loads, but only with such extra standing charges as may be incurred by its introduction. Of course, in the case of interest charges, if it should be found that the new load introduced extra items of capital expenditure, say in connection with services or mains, it should be debited with these.

It may also be postulated that, in addition to paying interest charges on such extra capital, the load should bring in a margin of "net profit" also, to make it worth the catering for.

A restricted-hour load, advocated by the author in a previous paper and not infrequently catered for, is an attempt to partly fulfil the above conditions; but, obviously, it suffers from serious limitations owing to day fogs, as well as having great drawbacks from the point of view of the customer.

Storage.

It will be fairly obvious that the only way to provide a load of the above greatly-to-be-desired nature (*i.e.*, not merely a "restricted-hour" load), and one which shall not, at the same time, inconvenience the customer, is by means of storage of the power, either at the sub-station or, failing that, at the main station. But the weak point of this scheme is its financial aspect. If we put the batteries either at the main station or at the sub-stations, we must still charge consumers all existing interest, &c., charges, as well as all "standing" charges incurred outside the station; and the question then resolves itself into the capital charges, working expenses, and maintenance of the cells (including transformation losses), being less, or more, than the interest and standing charges saved on the generating plant.

Personally, the author is of opinion that in most cases the balance in favour of the employment of the cells under such conditions is very small, the scheme being seriously hampered by those interest and other standby charges which are *not* cancelled by the introduction of the cells; also by the fact that it is impossible to differentiate between power and light, and between existing consumers and those on the new system. We are thus led to consider the question of placing the cells on the consumer's premises, and it is in this direction that the author believes success will most probably be attained.

At first the difficulties of capital cost of cells, and maintenance, as well as the supply voltage and the number of cells consequently necessary on each consumer's premises, may seem insuperable; but, on the other hand, there are the advantages of having a reserve current supply on the premises.

The standing and interest charges saved to the station and mains are of the order of ¾d. to 1¼d. per unit, while the charges incurred on account of the cells are not above ½d., and in most cases this would provide for a complete renewal of the plates every five years.

Conclusions.

1. The total charge debitable on account of running costs is much lower than is generally considered to be the case, varying from 0.30d. in medium-sized stations to 0.20d. in the largest ones.
2. For an "ideal" load, this includes all items of expense right up to consumer's terminals, provided the mains already exist.
3. The coal charge is far away the heaviest item of the running expenses.
4. The "running" part of the coal charge is easily estimated for any one town as against any other; and for a given class of coal is sensibly constant over a large variety of stations.
5. A large "internal diversity factor" on a motor load may be a positive disadvantage.
6. Anything tending to improve the combined diversity factor of the three classes of load is to be strenuously encouraged.
7. Storage on consumer's premises, if it can be proved to be practicable, is the only known means of providing a load which could be made to at all times accommodate itself to the amount of spare capacity available from the other two classes of load, thus realising the highest average "combined diversity factor" possible.
8. The reduction of charge which could be made in many stations, by merely treating the "unproductive capital" charge in the way indicated by the author in his paper on "Standby Charges," is quite appreciable.

The last point, though not discussed in the present paper for lack of space, is introduced to make the paper more complete.

LIGHTING and Heating

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Lighting and Heating.

Mercury Vapour Lamps Operated by Induction.

Two American patents recently issued to Mr. Peter Cooper Hewitt are interesting as showing a method of operating mercury vapour lamps by induction. The object of the invention is to provide a lamp and method of lighting which shall yield a practical light without any conductor leading into the lamp, thus making it possible to dispense with any break or joint in the electric circuit. The following details of the system are abstracted from *The Western Electrician.*

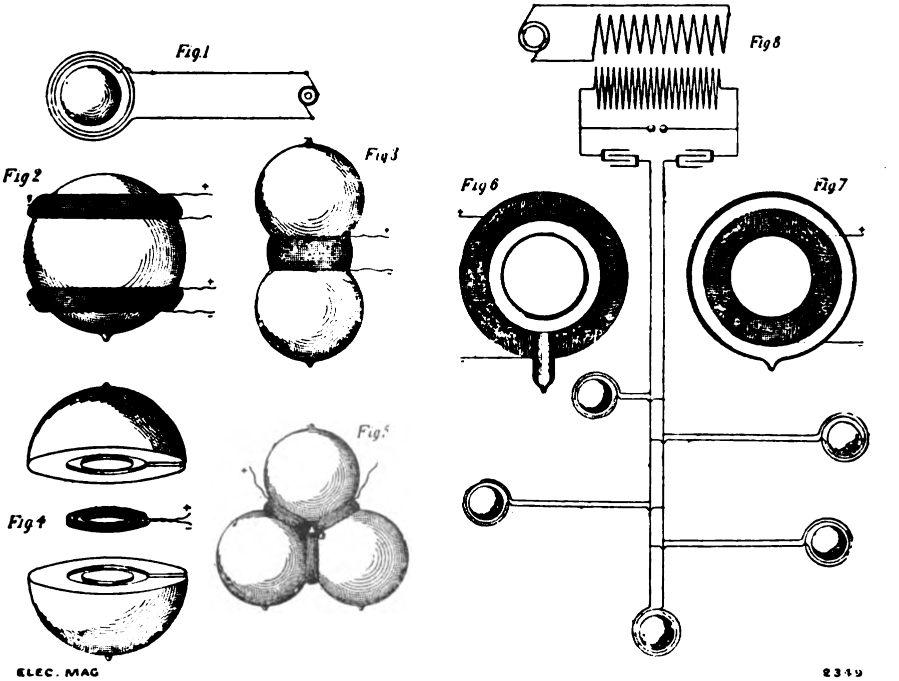
If there be substituted for the secondary coil of a transformer a closed circuit of some vapour or gas of the proper character and under the proper conditions, it will act as a conductor, and the energy of such current will be induced in it if the rate of change is suitable. The energy of such current will manifest itself in the form of light and heat if sufficient lines of force are cut by the vapour to overcome its tendency to resist becoming a conductor.

The induced current in the lamp and its voltage depend upon the general laws of induction, namely, the relation of the turns in the primary to those in the secondary, and the rate of change of the pulsations or variations in the actuating or primary current, or, in other words, the rate at which the magnetic lines due to the primary current are cut by the secondary circuit. This rate is the measure of the electromotive force given to the secondary circuit.

In the present form of lamp it is practicable to employ for the secondary circuit a simple closed circuit of vapour having effectively one turn in connection with a multiple-turn primary giving a suitable ratio of step-down transformation.

For the purpose of developing an electromotive force in the secondary sufficient to place it in a state where it will become readily conductive—that is, a true vapour conductor of low resistance—use is made of a current of such quantity and frequency as will induce in one turn of a secondary an electromotive force which shall be sufficient to break down the tendency of the vapour to resist becoming a conductor.

The vapour found most convenient in use is that obtained from mercury, because of its low resistance; but other materials may be used, the use of any vapour being dependent only upon the requirement that that there shall be induced in it a voltage sufficient to overcome its resistance. Certain impurities or vapours added to the vapours which are selected for forming the secondary or light-emitting circuit exercise such a resistance to the passage of the electric current that it is almost impossible with the most rapid variation of current to induce a secondary current in the lamp when they are present. Such vapours as will be obtained from water and some oxygen compounds seem to have this state of non-conductivity in a marked degree. Also the vapours usually present in a globe until it has been exhausted, heated, and the current induced in it, which current liberates more non-conducting vapours, would seem to render the desired state of conductivity almost impossible to attain; but by properly preparing the lamp and supplying the globe with the conducting vapour freed from the objectionable ones a condition is reached where a practical and enduring lamp is obtained. The vapour when in its conducting state being a conductor requiring a rate of change in the primary that will induce in a secondary of one turn an electromotive force of, say, from 3 to 50 volts per inch in case the secondary is, say, 3in. in diameter, the inducing current need not be over a few hundred volts when the current is passing, the voltage depending upon the material of the vapour, its density, and other conditions.



Cooper-Hewitt Induction Types of Mercury Vapour Lamps.

The amount of light emitted by the gas readily shows at what time during the process of manufacture the lamp is completed.

It is stated by the inventor that others have proposed certain lamps claimed to be induction lamps having a luminous band induced therein; but in none has any considerable amount of light been produced. This lamp yields a large quantity of light and possesses other characteristics which clearly distinguish it from the faint luminosity of the electrostatic effect produced in the other lamps alluded to. The difference is also at once apparent in the source of current.

Of the accompanying illustrations Fig. 1 is a diagrammatic view of one form of the lamp connected with a generator. Fig. 2 is an elevation of one form of the lamp, using two primary coils. Figs. 3, 4, 5, 6 and 7 are views showing other forms of lamp. Fig. 8 is a diagrammatic view of several lamps and a form of generator in circuit therewith.

These drawings explain themselves. On the passage of a current of the proper character through the primary coil a current is induced in the vapour, and immediately the vessel becomes brightly luminous. A change in position of the primary coil causes a corresponding change in the position of the luminosity. By increasing the amount of energy imparted from the primary source practically all the vapour in the lamp may be made to act as a secondary and to give the lamp a very intense brightness. The addition of a second coil on the globe of the vessel causes an increase of luminosity.

The operation of the lamp depends upon the possibility of obtaining a current of suitable rate of variation. Excellent results have been obtained by the use of the discharge currents obtained from condensers; but a properly constructed mechanical generator would produce the necessary current.

In Fig. 8 is represented diagrammatically one form of apparatus giving a rapidly varying current suitable for use to operate the lamp. The generator is to produce an alternating current of a frequency of about 125 periods to 300 periods per second, and of a voltage of, say, from 50 volts to 100 volts. The generator supplies the primary coil of a transformer, the secondary coil delivering an induced current of, say, 6000 volts. This induced current is delivered to condensers of suitable capacity, which may be arranged to be discharged through the line. It is preferable, however, to use two condensers as shown in the illustration, using the current induced between them for the supply of the main circuit. The discharge gaps limit the charge of the condensers and serve to discharge them. Each time the condensers are charged and discharged the current induced between them will flow back and forth through the line.

One of the glass vessels being placed in the field of its coil will act as a secondary, tapping off the amount of current that the lamp is constructed to take. The coil thus becomes the primary and the vapour in the vessel the secondary of the vapour transformer or lamp. With a pressure of 6000 volts and a bulb 6in. in diameter a coil of 15 turns will serve to illuminate the bulb.

The completed apparatus acts like an ordinary transformer, the primary in this case being the coil and the secondary being the light-giving part within it, with its contained vapour, or, more strictly, the contained vapour itself. Unless current is drawn off by the secondary the primary, as in an ordinary transformer, chokes back the current in the line and prevents the passage of current through the primary coil.

Electric Cooking.

THE following interesting summary of the advantages and difficulties of electric cooking forms the conclusion of a lengthy article by Mr. J. R. Cravath in *The Electrical World* and which is noteworthy in that it records the actual results obtained day by day in practice with complete electrical cooking outfits as for household use.

The specific advantages of the electrical over other methods of cooking are in part summarized as follows, although there are many good points that might well be elaborated more fully:—

1. Considerable cooking can be effected on the dining-room table. This appeals strongly to those who are doing light housekeeping or, in fact, to any family where the lady of the house does part or all of the cooking. Unless cooking can be done on the table she is likely to be absent in the kitchen during part of the meal, especially at breakfast, when time is limited.

2. Vegetables cooked in the kitchen for dinner can be brought on the dining-room table in the original dish in which they were cooked. This means a saving in time and saving in dish-washing, to say nothing of the fact that the food remains hot better than if put into another dish.

3. The heat given out during cooking is not enough to raise perceptibly the temperature of either kitchen or dining-room. Consequently it is the ideal method of cooking for hot weather. The average kitchen is too hot to work in comfortably most of the time while cooking is going on.

4. No products of combustion are thrown out into the air of a room, as in the case of a gas stove. The air in the kitchen is noticeably better with electric cooking than with gas. There is none of that smell of the products of combustion so noticeable in a kitchen where a number of open gas flames are burning.

5. The rate of cooking can be definitely and quickly regulated as it cannot be with coal or gas. This is specially valuable in boiling food, which will stick to the bottom if boiled too hard. With care, certain breakfast foods can be cooked without using a double cooker—a feat practically impossible without constant attention with gas. Electric cooking utensils can be made to give the desirable slow heat more like that of a hard coal fire than gas, but the electric devices

are under better control than the coal fire. This makes it easier to cook food at the proper rate without having it overdone in one place and underdone in another.

6. Electric cooking utensils are much pleasanter to wash than pots and pans used in cooking over gas or coal, as there is no soot to wash off. The dish-washing is therefore not as disagreeable.

7. There is no flame to be blown out by the wind and cause danger of explosion or trouble with the flame catching back, as in the case of gas and gasoline. This means that the breeze can be allowed to blow through the kitchen in summer as it could not be if gas or gasoline were used.

8. There is practically no fire risk with electric cooking utensils as there is with coal, gas and gasoline.

9. The cost for current for an electric cooking installation with a rate of 3d. per kw.-hour will not be greater than that of a hard-coal range, and it is incomparably more convenient than any kind of coal fire, for which coal and ashes have to be handled and fires built.

The advantages of the electric iron are already well known. There are some difficulties in connection with the introduction of electric cooking which it is well for those in the business to thoroughly understand and be prepared to meet.

A full electric cooking outfit for the kitchen costs more to install than a gas range to do the same things, although as to the dining-room table end, there can be no comparison, because gas is out of the question there.

There is also no question but that, at any rate with current above 1½d. per kw.-hour, gas at 4s. a thousand is cheaper than electricity for cooking, considering only the monthly gas bills *versus* the monthly electric bills, and leaving out of account the fact that things can be done with electricity that cannot be done with gas.

When it comes to heating large quantities of water or other liquid, the largest burners on an ordinary gas range will heat more rapidly than the ordinary electric stoves or water boilers. Either one, however, is rapid enough. The most serious problem to be met in connection with water heating is that of supplying large quantities of water for dish-washing and other domestic uses in houses where there is no other means of heating the water than the kitchen stove or range.

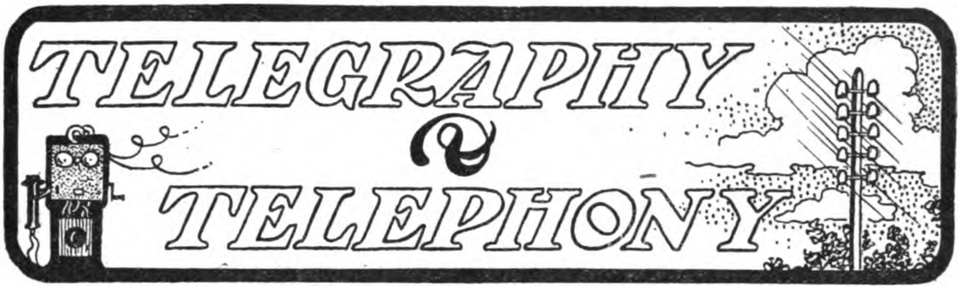
Another difficulty to be met in the first introduction of electric cooking is that the housekeeper is usually equipped with a large assortment of pots and pans which can be used over a gas or coal stove, so that she is not at all limited as to the number of cooking dishes. The cost of electric cooking utensils naturally will keep down the number purchased to those actually necessary; so that some housekeepers will feel that they are somewhat hampered by having so few utensils.

Taking up these difficulties in the order named, we must remember that electric light is not driving out gas on the basis of cost alone, but on account of its cleanliness, convenience, and coolness. It is, therefore, entirely reasonable to suppose that electric cooking can be introduced against gas for the same reason. It is not to be expected that it will be introduced much where all the cooking is done by servants and where the house-owner looks merely at the amount of his gas or electric bills. Where the lady of the house does her own cooking and where the family income makes electric cooking within reach, it will find most rapid introduction. It will probably come in first in flats and apartment buildings for light housekeeping because of its convenience and freedom from heat and bad air.

The second difficulty—that of providing hot water—is usually taken care of in flats and apartment buildings by a hot water supply for the whole building, and in the better class of residences, by small coal or gas hot-water heaters or furnace heater coils in the basement.

The difficulty of the limited number of cooking utensils disappears after the housekeeper gets used to electric cooking and learns to plan her cooking to best advantage and to get the best possible use out of the utensils she has. Cooking with ordinary enamelled ware utensils on an electric disc stove is not by any means satisfactory, as it is very slow and inefficient. Utensils should either be clamped on these stoves or be constructed with the heating element in the utensil itself.

CENTRAL STATION MANAGERS can increase their sales by communicating with The ELECTRICAL PUBLICITY BUREAU, 4, Southampton Row, London, W.C.



For titles of all important Telegraph and Telephone articles of the month, see World's Electrical Literature Section.

Simultaneous Telephone and Telegraph.

F. M. SLOUGH and M. E. TAYLOR.

FOR a long time the first expense for apparatus used for simultaneous telephone and telegraph service retarded commercial recognition of its industrial value, due to the fact that expensive and complicated equipment had been supposed necessary for its operation; besides, the results were very uncertain. Long and careful study, with practical results, have, however, within the last few years placed simultaneous telephone and telegraph in such harmony that all of the larger long-distance toll companies are adopting it on account of the large revenue which can be secured with a very small extra expense by leasing the wires for telegraph service to parties desiring the same, such as brokers, newspapers, &c.

In taking up this subject the writers have decided to discuss only the practical methods such as have been used under service conditions with good results; also to give briefly the different methods by which these results may be obtained, and as far as possible explain the advantages and disadvantages of the several methods, which may be divided into two systems—simplex and composite.

Simplex systems are based on the Wheatstone's bridge principle, and are capable of rendering only one telegraph circuit from one metallic line, while the composite systems are based on the different effects which the alternating current has on condensers and impedance coils, and provides for two complete telegraph circuits over the same metallic line.

We will first take up the simplex system, as it is the simplest and the first that was used to any great extent. It will be necessary to subdivide this method into the impedance and repeating coil systems, either of which have their own advantages.

Fig. 1 shows a toll line which represents the natural condition of any toll circuit as it exists between two exchanges described as *A* and *B*.

The first step in cutting in a telegraph circuit by the impedance simplex method without interfering with the telephonic use of this line is clearly shown in Fig. 2, in which it will be noted that an impedance coil is cut in at each end of the line, *C1* and *C2*. These coils do not cut down the transmission of speech to any noticeable extent for the reason that they offer a high impedance to the high-frequency voice currents, and are so wound that a middle tap can be brought out of the winding and which is connected to the telegraph instruments through battery to ground.

These coils may be made up in the same

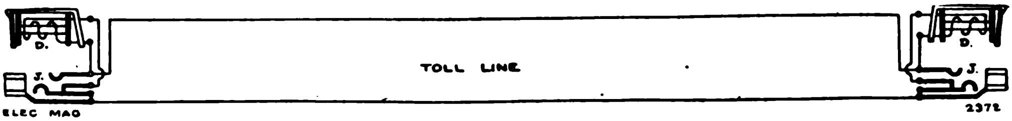


Fig. 1. Toll Line Telephone Circuit.

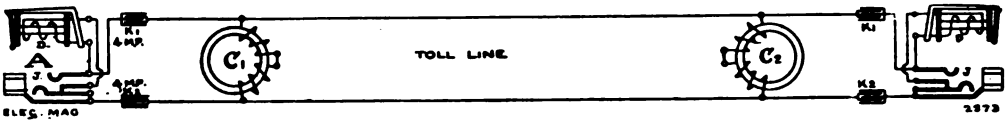


FIG. 2. TOLL LINE AND SIMPLEX TELEGRAPH ARRANGEMENT.

manner as a repeating coil, or for cheaper installations the two coils of an ordinary ringer will suffice, care being taken to have them of sufficient resistance as not to cut down the telephonic transmission to a very great extent. However, it is never good practice to have them wound too high, because it will then be necessary to use an extremely high voltage to operate the telegraph relay at the distant point. Coils having a closed magnetic circuit are best for this purpose, as when wound to only a moderate resistance they still offer a high impedance to voice currents as before stated, permitting a low voltage to be used for telegraphing.

It will also be noticed in Fig. 2 that condensers *K1* and *K2* are cut in on each side of the circuit between the line jacks and impedance coils, and serve the purpose of keeping the telegraph current from passing over the local subscribers' line, which is liable to grounds and crosses which would seriously interfere with telegraph service.

As these condensers are intended to allow the voice and ringing currents to pass through without diminution, it is important that they be of a moderately high capacity, say 4m.f. These condensers can most easily be procured of a capacity of 2m.f., and if these are used it will be necessary to use two condensers instead of the single 4m.f., and the same results will be obtained.

The advantage claimed for the impedance coil system is the small cutting down of telephone transmission and the good ringing results, so long as the line and all connections connected thereto are perfectly clear from ground. This latter feature is a failure in a great many instances, from the fact that few exchanges can use their power and hand generators for ringing without receiving ground connections in some manner; which has a tendency to operate the telegraph relay and greatly affect that service. The unbalancing of the line by any permanent or swinging ground connection causes the telegraph impulses to be audible in the telephone receiver. Any connection from the line to ground will cause trouble in any system and so far as practicable should be avoided.

It is therefore obvious that this method could not be used where the line is likely to be connected to lines which operate on the common or ground-return system or are unbalanced to a very great extent.

It is also necessary to have an absolutely ungrounded generator to ring down the drop at the distant end of the line; as a grounded generator would interfere with the telegraph instruments when connected to the line. Yet, when the line can be kept entirely clear from ground connections, the impedance service is preferable. As stated, both the telephone transmission is excellent and the ringing is very satisfactory.

These troubles are for the most part absent when repeating coils are used, as there is no direct connection between the switchboard jacks and toll lines, the same being perfectly insulated from each other, due to the fact that they are connected to separate windings on the coil.

The principal trouble with repeating coils is their inefficiency for both talking and

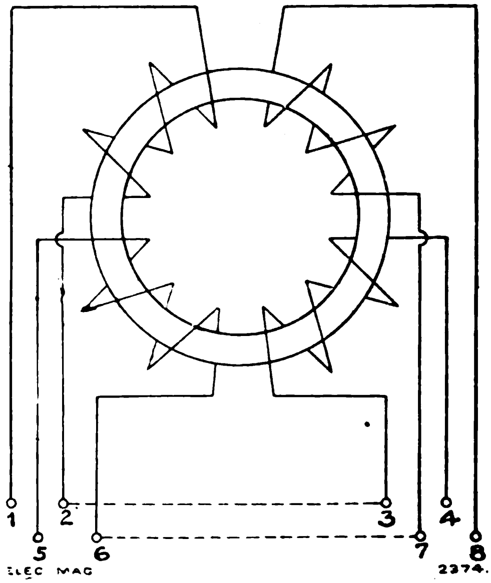


FIG. 3. SIMPLEX REPEATING COIL CONNECTIONS.

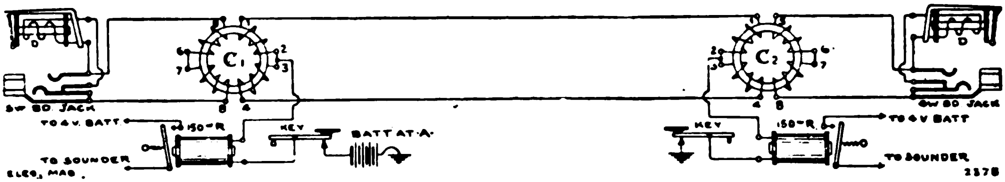


Fig. 4. Telephone Line with Superposed Telegraph Circuit.

ringing currents, due to the well-known fact that a coil built for ringing currents which are of a comparatively low frequency, about 20 cycles per second being the average, is inefficient for the high-frequency voice currents, which average 750 cycles per second, and *vice versâ*; a coil built for both, as is essential in this work, is necessarily a compromise between the two designs, and consequently somewhat inefficient for both purposes.

Where the repeating coils are used in place of the coils already described, it is obvious that condensers *K1* and *K2* can be omitted, as the line and switchboard windings of the repeating coil are insulated, one from the other.

Repeating coils for this purpose are generally of the closed magnetic circuit type, and are designed so as to allow ringing currents and voice currents to pass through with very little loss.

Many coils for this purpose have been designed and, in general, nearly all have the same characteristics, viz.: A closed magnetic circuit, with four separate windings, the whole to be enclosed in an iron tube which effectually prevents cross talk from one coil to others adjacent to it, and also protects the coil from injury, &c.

It is well to use coils, the four windings of which are equal in resistance and number of turns, and which are also so placed on the core as to have the same electrical effect. This is done commercially in several ways, by different manufacturers, each of which has its own advantages.

This method of operating simultaneous telephone and telegraph has become very popular with both large and small toll companies for the reason that the ground ringing current does not affect the telegraph conditions, neither are the telegraphic impulses so noticeable in the telephone circuit. Fig. 3 shows the connecting contacts and windings of a repeating coil adapted to the repeating coil simplex system. Coils *1*, *2* and *3*, *4* are connected as one coil at terminals *2* and *3*, as illustrated, and as toll line side of coil. Coils *5*, *6* and *7*, *8* connected at *6* and *7* represent the switchboard side of coil. Telegraph connections at *2* on line side of coil are commonly called the leg of the coil and will be expressed, hereafter, by that term.

It is readily seen that, by this construction, the centre point of the coil can easily be secured for telegraph connection. It has been found that coils having four insulated wires twisted together and wound on the same core, give excellent results, as with this arrangement the four coils can be nearly balanced—the vital features in simultaneous telephone and telegraph operating.

The resistance to which these coils should be wound depends much on the nature of the lines in which they are to be connected. If the line is liable to be unbalanced to a very great extent it is best to use a coil, the windings of which are rather high in resistance, and the reverse is also true, that is, a very low-wound coil can be used to advantage on a very well balanced line.

For a coil that will meet the conditions most commonly met with in practice the writers would suggest a coil not lower than 100 ohms and not higher than 200 ohms, per winding, the lower figures being used wherever possible, as the telephone transmission is better.

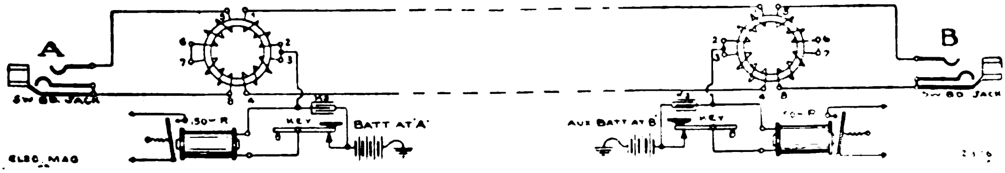


Fig. 5. Combined Telephone and Telegraph Circuit.

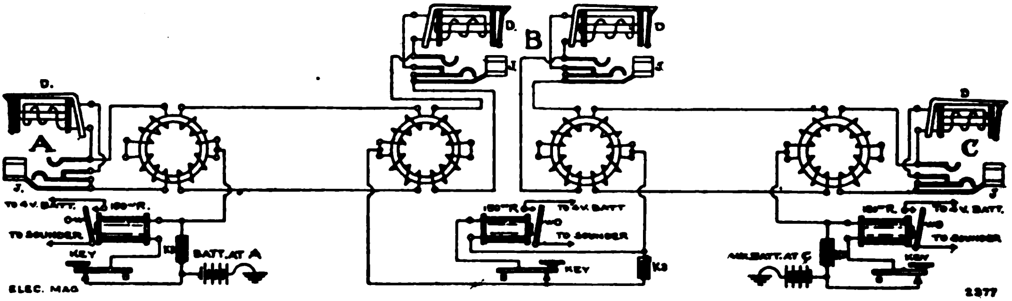


FIG. 6. INTERMEDIATE TELEPHONE AND TELEGRAPH STATIONS.

In Fig. 3 and, in fact, in all future figures relating to simplex circuits the repeating coil system only is shown, it being understood that with a few exceptions (hereafter noted) the electrical action is the same.

The most common arrangement of the telegraph circuit is shown in Fig. 4, complete, so far as the operation of the telegraph instruments are concerned, and it will be seen that when the telegraph operator at *A* depresses his key, he sends an impulse of direct current over each wire of the pair simultaneously, the current dividing at *T* and traversing each half of the coil winding *C1* in opposite directions, equal quantities of current travelling over each line wire *L1* and *L2*, and thence to return to ground at *B* in the same manner as at *A*; the path taken being shown by single-headed arrows.

The telephone circuit is metallic, and is not affected by this telegraph current for the same reason that in a balanced Wheatstone's bridge the galvanometer needle is not affected when the battery key is depressed or released. The telegraph legs correspond to the battery supply, telephone receivers correspond to the galvanometer and the line wires, and the coil windings correspond to the four branches of the Wheatstone's bridge.

A perfectly balanced coil on a good line will permit a highly efficient telephone receiver to respond to a small extent to the telegraphic impulses, if some arrangement is not provided for taking up the discharge of the circuit and smoothing the telegraph wave. Any telephone man knows that there are very few lines which are considered good that are perfectly balanced; and, therefore, the system must be able to stand a slight unbalance of line conditions without any serious results. The telegraphic impulse, as it is impressed on the telephone circuit, changes rapidly in strength, rising almost instantly to a maximum, remaining there a period of time corresponding to the time the key is depressed and then falling to zero when the key is released; also the coils in the circuit discharge at this time, which causes the telegraphic impulse to terminate with a high peak.

These sudden changes would have a great deal of influence on the slightly unbalanced telephone circuit, and in order to make this influence as small as possible, capacity or inductance or both are so placed in the circuit that they have a retarding effect and the charges are accomplished at a slower rate.

A condenser of from 4m.f. to 10m.f. placed in the circuit, as *K3* as in Fig. 5, has a smoothing effect on the telegraph wave and causes it to have a great deal less effect on the telegraph wave, and less effect on the telephone circuit than before.

A condenser connected in this manner has a reaction which opposes the counter e.m.f. due to the inductance of the line and instruments which rises rapidly when the circuit is broken by the telegraph key, as before stated, and tends to make it cause less interference in the telephone sets than it otherwise would.

If the condenser is placed merely around

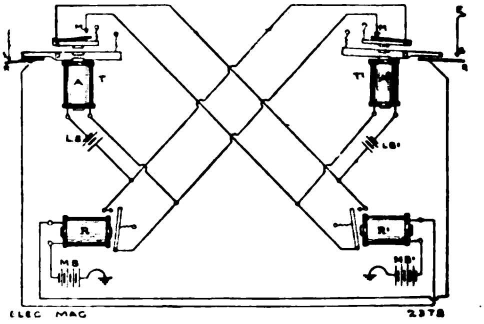


FIG. 7. GHEGAN TELEGRAPH REPEATER CIRCUIT.

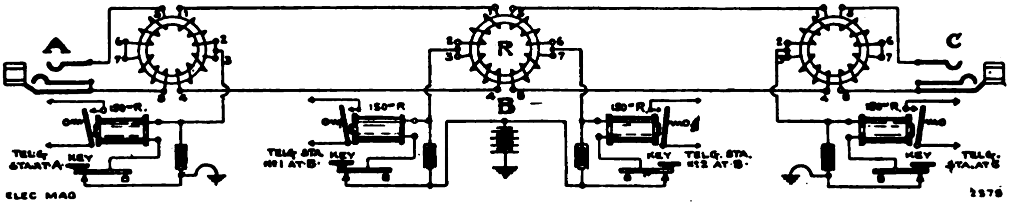


Fig. 8. Through Telephone Service and Intermediate Telegraph Stations.

the telegraph key it seems to work equally well and at the same time does not slow down the operation of the local telegraph relay, as is the case when placed in multiple with the entire instrument. This former arrangement is found to give results which are quite satisfactory, except that there is a tendency for sparking to ensue at the key contacts, especially where a high voltage is used.

It will be noticed, by following the telegraph circuit in the illustrations, that the current is equally divided on either side of the line; or, in other words, the metallic line represents the same as one conductor. Thus the line may be crossed or one side may be open and the telegraph will still continue to operate, but it will be seen, however, that under either of these conditions the telephone circuit is out of commission.

Fig. 6 shows theoretically how a telegraph circuit is connected through an intermediate station, *B* representing the intermediate connection.

The toll line from *A* to *B* and the one from *B* to *C* are separate lines and used as such for toll service, while they represent but one continuous line for telegraph purpose. Fig. 6 shows a telegraph station to be connected at the intermediate station *B*, which is supplied by battery from station *A* to *C*. In this illustration also is shown another battery connected from ground to the telegraph line through the Morse instruments, at *C*, this battery acting as a booster to the battery at *A*, and compensating for loss of current along the line due to leakage, which amounts to quite a loss of efficiency, especially if the line is a very long one.

Often at an intermediate station, such as *B*, a special repeater is placed in the circuit which acts as a two-way relay; that is, when actuated by weak impulses of battery from either direction *A* or *C*, that it sends the same kind of impulses from an auxiliary battery in the opposite direction, this action being clearly shown in the circuits of this so-called Ghegan repeater in Fig. 7, which is connected in place of the ordinary telegraph relay at *B*, as in Fig. 6.

Often it is desired to terminate two telegraph circuits at the intermediate station *B*, and leave the telephone line connected through. This can best be done in a manner similar to that shown in Fig. 6, except that each telegraph leg of the coil belongs to a different telegraph circuit, and as instead of two telephone circuits we have only one, it will only be necessary to use one repeating coil designated by *R* in Fig. 8. —*Sound Waves.*

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The Preservation of Poles and Timber.

J. J. KESSLER.

After timber has been cut and put into use, its life is determined by its environment.

Every one is familiar with the fact that in some instances timber has been in use for many generations without showing any sign of decay, and that, in other cases, timber of equally good origin has lasted but a short time.

Decay is most frequently caused by the lower forms of plant and animal life. The chemical constituents of the wood are attacked by these organisms, fungi, and bacteria, changing their chemical nature. Part of the resulting compounds are absorbed as food, and there is left behind a substance of no mechanical strength and perfectly useless. The parasites which destroy the wood in this way thrive best where the timber is exposed to both moisture and air. This is readily noticed in the case of fence posts, telephone poles, and in piles, where decay starts at the point where the poles leave the ground or the piles the water. Timber that has not been seasoned succumbs most readily to decay, favouring as it does the existence of its destructive enemies on account of the moisture present. Timber that is immersed wholly in pure water will not decay owing to the lack of oxygen necessary for the life and propagation of these bacteria and fungi.

Wood preservatives are substances which prevent decay either by the exclusion of moisture, or by preventing the growth of micro-organisms. In order to absolutely exclude moisture, wood must be impregnated, or rather filled, with water-insoluble substances. All liquids and gases must first be removed and the space occupied by them filled with the preservative compound. It is impossible to accomplish this by simply dipping the pieces to be tested. A decrease of pressure is required, together with higher temperatures, to expel all moisture and much of the air. Then, when the wood is immersed in the impregnating compound, pressure must be applied in order to force it through the pores and fill them up. The preservative compound must be fluid enough to pass through these pores, but not so fluid that it will run out again under service conditions.

When *completely* filled up with a correct waterproof substance, correct with respect to its physical properties, wood may be said to be perfectly preserved. It will never rot as long as it remains filled up. It may wear out mechanically, but not chemically.

By use of the second class of wood-preserving compounds, each cell must be sterilized. It need not be filled up with a solid in order to accomplish this. A small amount of substance will do, and water need not be excluded. The sterilizer must be in a liquid condition as it enters the wood. If inorganic salts, such as copper sulphate or zinc chloride, are used, they are first dissolved in water. Organic antiseptic substances, such as phenol (carbolic acid), naphthalene, &c., may be in the tar oils in which they are present. One would imagine that any substance dissolved in water could not be as effective as an oil solution because, first of the tendency of the water-soluble compound to be washed or dissolved out again; and, second, the presence of the oil would help to fill up the pores, exclude moisture, and tend to keep the preservative dissolved in it in place. The advantage of this second method of preservation has been fairly proved in practice.

The German postal and telegraph department recently published statistics collected during a period of 52 years on the life of poles impregnated with different preservative substances. The number of poles under observation was nearly 3,000,000, and the following results were obtained:—

Poles impregnated with:	Life, years:
Copper sulphate...	11.7
Mercuric chloride (corrosive sublimate)...	13.7
Heavy tar oil	20.6
Unimpregnated	7.7

In order to get the best results, of course, the treatment must be thorough. What constitutes thorough treatment can only be found after considerable experience. As an example of the improvement effected in copper sulphate treatment, in 1883 the average life of the German poles cited above was 9.4 years, while in 1903 the method of treatment had been improved so that an average life of 13.3 years was obtained.

Although the method of partially filling up wood with antiseptic substances is not as effective as completely filling it up with absolutely waterproof substances, for practical and economic reasons the antiseptic treatment is the only one used on a commercial scale. The whole problem hinges on the cost of the wood. A French engineer considers it very profitable to spend from 2s. to 3s. on a tie costing from 4s. to 6s. when he can increase its life from 7 to 30 years. He spends more money than his German *confrère*, who can procure wood more cheaply.

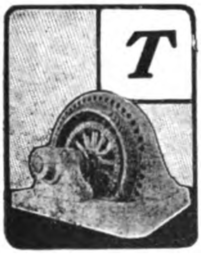
Zinc chloride has given good results on some railway lines in Germany: copper sulphate has done well, too. It is worthy of comment that poles and ties in Europe are almost universally treated with some preserving compound. The increasing need of it is being felt in America. Wood is increasing in value. The American railways renew 110,000,000 ties every year. The Bell Telephone Company has 8,000,000 poles in use, varying from 20ft. to 90ft. in length, of which 800,000 poles were added during the past year. In 1887 the number of renewals was estimated as 70,000,000. There are no statistics showing the number used by independent telephone systems.

Forestry engineers have already been called into existence to establish methods of cutting timber to insure a regular supply, and to study the problem of increasing the length of service of the material.—*Sound Waves.*

Every aspect of the design and manufacture of electrical apparatus is dealt with in this section month by month, and Engineers connected with large manufacturing concerns are especially invited to contribute.

*A New Type of Induction Motor.**

LOUIS J. HUNT.



THE motor described possesses all the characteristics of the ordinary type of slip-ring induction motor, but differs from it in the arrangement of the windings. These are arranged to permit of the starting or regulating resistances being connected to the stator windings instead of to slip-rings as in the ordinary manner. The machine is an improved form of "cascade" motor, having two magnetic field systems superimposed upon one another in the same core body. The second field has its origin in the rotor, and consequently induces secondary currents in the stator windings.

The author described at some length, and with the aid of illustrations, the more noteworthy inventions and improvements introduced during recent years in induction motor design as for variable-speed working. These he classifies generally into two divisions, the first including motors depending upon suitable spacing of the stator windings to ensure non-interlinking of the two fields, and the second including machines provided with two stator windings wound for dissimilar numbers of poles.

The new motor, which has been developed by the Sandycroft Foundry Company, Ltd., belongs to the second group, the two numbers of poles being so chosen that when divided by their greatest common factor the quotient is in one case an even and in the other an odd number. This ensures non-interlinking of the two windings except by the agency of the rotor.

Fig. 1 shows the general arrangement of this motor, from which it will be seen that it closely resembles in design the ordinary type of machine.

The stator carries a single winding, and is provided with terminals for connecting to the supply mains, and with tappings which are connected in pairs through resistances whilst starting or when rheostatic speed control is desired, and are short-circuited at normal speed. The rotor is provided with a short-circuited winding without slip-rings, unless designed to run at more than one efficient speed.

The chief difficulties to be overcome in the design of a "cascade" motor are greatly

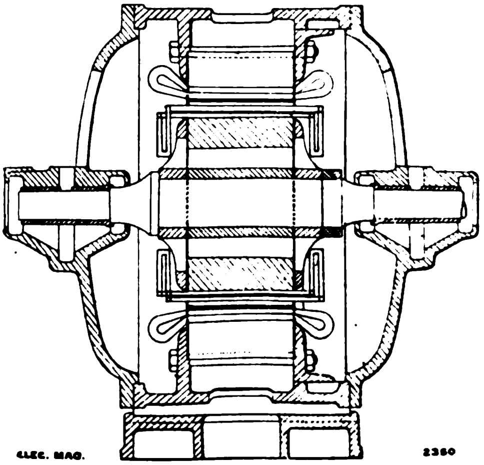


FIG. 1.

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* Abstract of paper read before the Manchester Section of the Institution of Electrical Engineers, March 19, 1907.

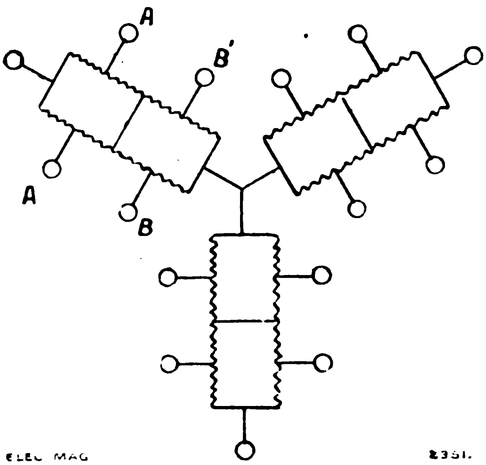

FIG. 2.

increased magnetic leakage and C²R losses. Where two stator windings are used the inductance of the one occupying that portion of the slots farthest removed from the rotor is very large, owing to the increased leakage from tooth to tooth.

In experiments which were made on a motor wound with separate 8-pole and 4-pole stator windings, the former being placed nearest to the rotor, it was found that the leakage per ampere-turn per inch length of core (after deducting the leakage of the end connections) was 7.0 in the case of the 8-pole winding, and 11.4 in the case of the 4-pole winding. The pole pitch of the 4-pole winding was, of course, twice that of the 8-pole, and if the conductors had occupied the position of the 8-pole winding, the leakage would have been certainly not more than 6.0 lines. By using one stator winding only, this difficulty was overcome, and experiments on the same motor showed that the power factor and overload capacity were much increased, although only two-thirds of the copper was used. The stator windings are parallel wound, and each pair of tappings connects two points of the winding between which there is no "primary" difference of potential. Fig. 2 shows diagrammatically a three-phase primary, six-phase secondary stator winding.

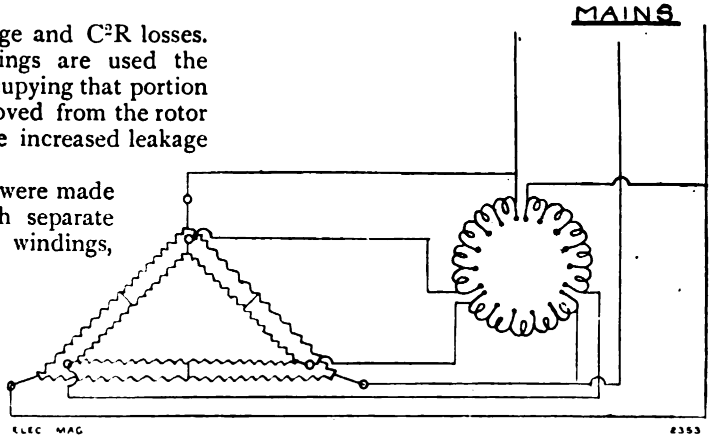

FIG. 4.

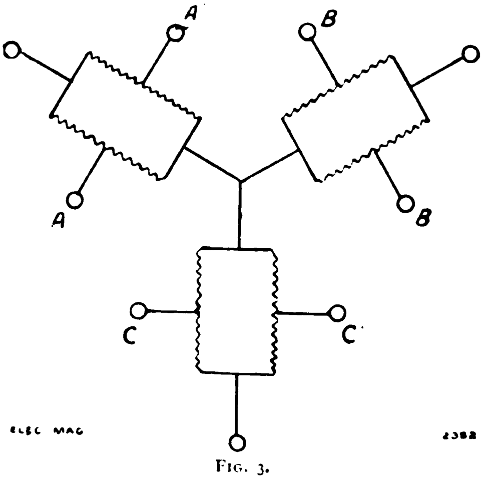

FIG. 3.

The mains are coupled to the three terminals of the "star," and the starting resistances, arranged for two-phase currents, are connected to the tappings A, A' and B, B'; the remaining tappings are connected to a 4-pole switch mounted on the motor casing, and are short-circuited after the machine has reached its normal speed. This winding, although involving the use of a short-circuiting switch, is preferred for constant speed motors, as the magnetic leakage and C²R losses are rather less than would be the case if the windings were tapped for three-phase currents only. The currents in each branch are in quadrature. The resultant stator current is equal to the geometrical sum of the primary and secondary currents, and may be anything in value between 1.07 and 1.2 times the primary current. The arrange-

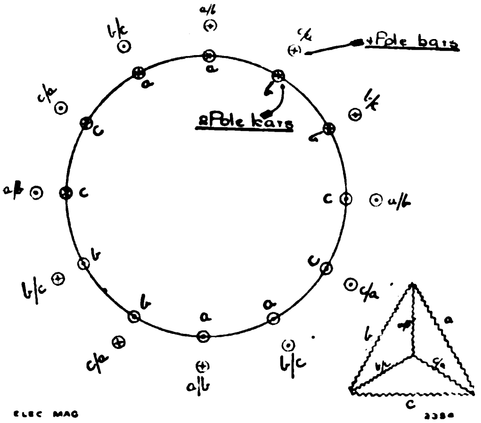

FIG. 5.

ment of the windings and the power factor of the motor determine the actual value of the current. In order to show how greatly the stator C²R loss is reduced by using a single parallel-wound winding instead of separate primary and secondary coils, the following table has been prepared. The machine is wound for 12 poles, the primary field having 8 and the secondary 4 poles.

For motors designed for variable-speed work, with rheostatic control, it is preferable to tap the stator windings for two or three-phase secondary currents in order that the whole of the windings may be active during the time when the tappings are not short-circuited. Fig. 3 shows diagrammatically a suitable winding for this purpose. The tappings A, A′ ; B, B′ ; C, C′ are connected to three independent resistances.

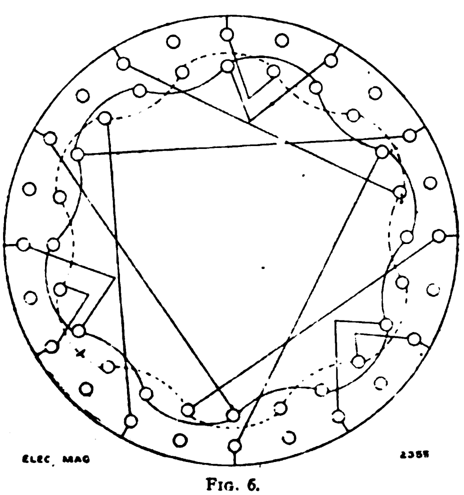

FIG. 6.

	Stator wound with separate Primary and Secondary Windings.	Stator wound with a single tapped Winding.
Size of slots..	1¼in. × 11/32in.	1¼in. × 11/32in.
Number of slots	72	72
Number of primary conductors per coil	2	2
Number of secondary conductors per coil.. ..	2	—
Cross section of each primary conductor (sq. mm.)	15.75	13.25 × 2 = 26.5
Cross section of each secondary conductor (sq. mm.)	6.75	—
Primary Current	62amp.	62amp.
Secondary ,, ...	27.0 ,,	—
Resultant ,, ...	—	73amp.
Current density in primary winding (amps. per sq. mm.)	3.93 ,,	2.75
Current density in secondary winding	4.0 ,,	—
Mean length of one primary turn	34in.	34in.
Mean length of one secondary turn	50in.	—
Total length of primary winding	408ft.	408ft.
Total length of secondary winding	600ft.	—
Resistance of primary windings (hot)	.155 ohms	.088 ohms.
Resistance of secondary windings (hot)	.54 ,,	—
Primary C²R losses (hot)	595 watts	468 watts.
Secondary ,, ,,	393 ,,	—
Total Stator C²R losses ..	988 ,,	468 watts.
Total weight of Stator Copper	62 3lb.	64.6lb.

Another form of winding, "mesh"-connected, is shown in Fig. 4, arranged for three-phase tappings. This requires only six terminals, as three are common to both primary and secondary currents. The whole of the stator windings are not, however, active until the tappings are short-circuited.

Referring now to the rotor, a large number of different methods of winding are possible. It is important to keep the rotor C²R losses as small as possible in order to ensure a high efficiency, and also to reduce the drop in voltage between the primary and secondary parts of the machine. The voltage drop has an important bearing on the performance of the motor as, omitting consideration of the inductance, the magnitude of the second flux depends upon it. If the CR drop be large, the overload capacity will be prejudicially affected.

The rotor may be provided with two separate windings, one wound for "*x*" number of poles and the other for "*y*" number of poles, the two being inter-connected. In this case the currents induced in the "*x*" pole winding flow into the "*y*" pole conductors, and produce the second

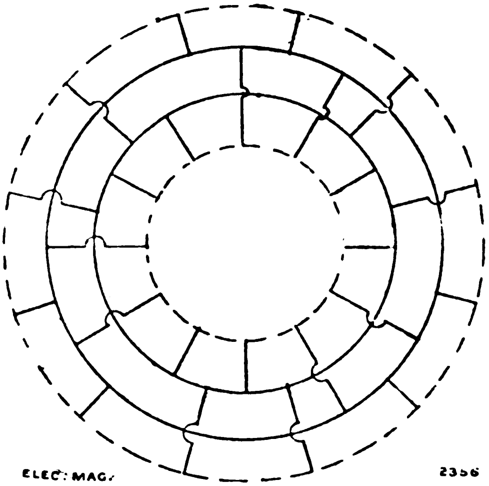

FIG. 7.

magnetic field. It may be here stated that the objection raised to the two separate stator windings does not apply to the rotor, as the frequency of the currents is the same in both rotor windings. In fact, the local leakage lines are due to the resultants of the currents in the two sets of conductors, and by suitable arrangement the total inductance of the two windings may be made less than the sum of the inductances considered separately. Fig. 5 shows a rotor having two windings, one connected for four poles and the other for two poles. The former is "star" and the latter "mesh" connected. The 4-pole ampere-turns are consequently equal to 1.73 times the 2-pole ampere-turns. Only one slot per pole per phase is shown in the diagram.

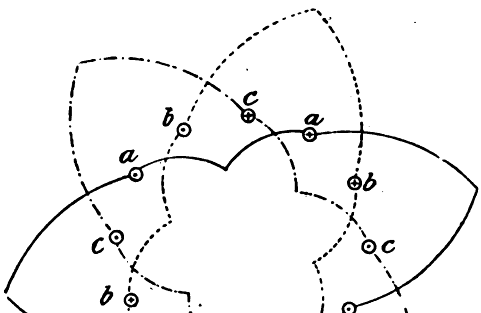

FIG. 8

Instead of grouping the bars in two separate three-phase windings, the 4-pole and 2-pole conductors may be connected to form a winding, as shown in Fig. 6.

This arrangement reduces the length of copper required in the end connections, and has the same effect as two separate windings. The 2-pole bars are connected to form two "mesh" windings, as shown. Each 4-pole bar is connected at one end to a 2-pole bar, and at the other to a short-circuiting ring. There are two of these rings, one at each end of the rotor; only the connections at one end of the rotor are shown. Those at the opposite end are duplicates of these. The outside circle represents one of the short-circuiting rings. The inner ring of small circles are the 2-pole bars, the outer ring the 4-pole conductors. Fig. 7 shows this winding diagrammatically. The dotted circles are the short-circuiting rings and the full-line ones the "mesh"-connected 2-pole conductors. Each radial line represents a 4-pole bar.

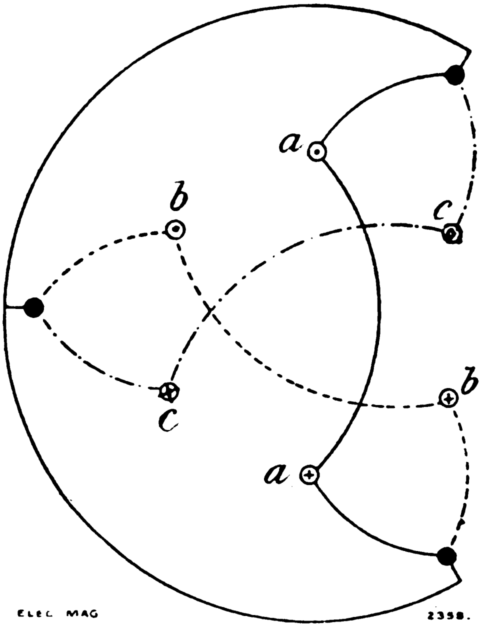

FIG. 9.

A (4 + 2) pole winding has been shown, but it may be mentioned that as the resultant magnetic field is not symmetrical, a motor having this number of poles is not satisfactory. If, however, diagrams had

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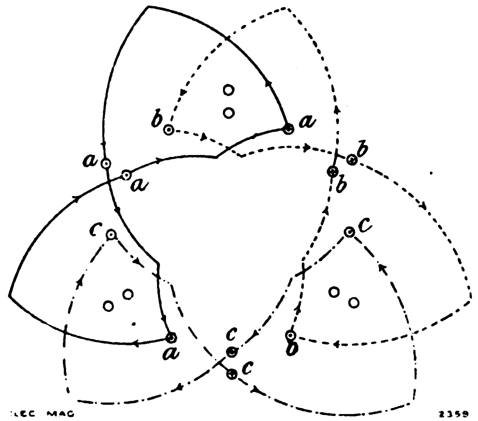

FIG. 10.

been prepared for a larger number of poles they would have been confusing when reduced to a small scale.

It has already been mentioned that the currents of the two rotor windings in any one slot may be algebraically added together and considered as one current. By a suitable arrangement of the connections one winding may therefore be substituted for the two, and the total C^2R losses reduced to that of the "x" pole winding only. Figs. 8 and 9 show the directions of the currents in 4-pole and 2-pole windings at the instant when the current in the "a" phase is equal to m, and those in the "b" and "c" phases to $\frac{m}{2}$. Two-pole bars occupy only one-half of the slots.

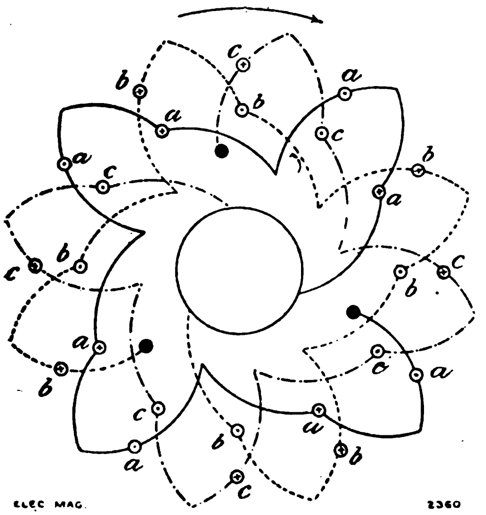

FIG. 11.

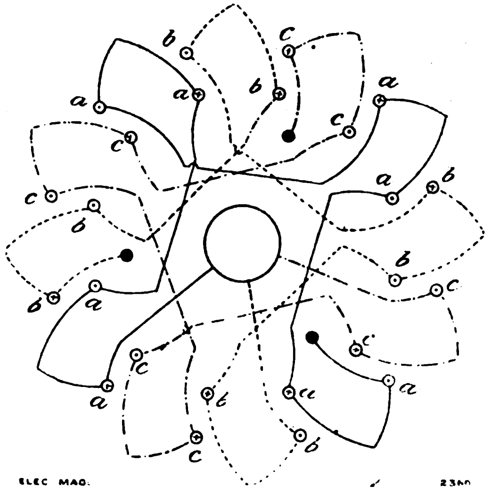

FIG. 12.

By super-imposing one diagram upon the other, it will be seen that some of the currents cancel one another. The resultant diagram is shown in Fig. 10.

The number of conductors and the total length of the end connections are equal to those of the 4-pole winding only. On the score of low copper loss this is a very good winding, but it has two serious faults; the slots are deep owing to the concentration of the conductors, and the inductance for the same reason is considerably higher than that of the windings already described. Experiments were made with a small 12-pole motor, the rotor of which was provided with

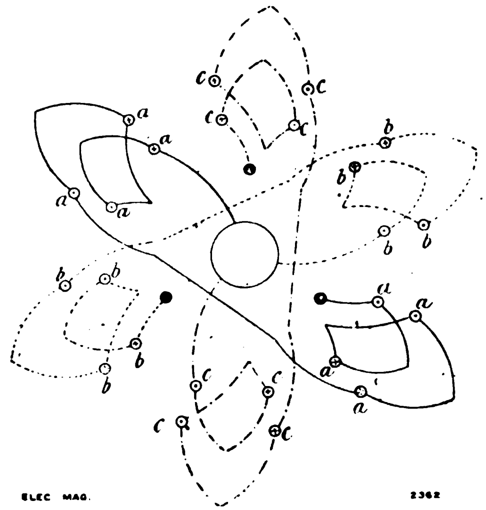

FIG. 13.

double windings similar to those shown in Fig. 5. After tests had been made, it was rewound with a single winding as shown in Fig. 10. The double winding gave a power factor of .78 and the single winding .72. These results were obtained with a double-wound stator. The 8-pole stator winding was then re-connected and provided with six-phase tappings, and further tests showed a rise in power factor from .78 to .81. The efficiency was, of course, higher with the single than with the double rotor winding. One may extend the list of resultant windings indefinitely, but one further example will serve for the purpose of this paper. Figs. 11 and 12 show 8-pole and 4-pole windings. The one shown in Fig. 12 is, strictly speaking, a six-phase winding, as there are six groups of conductors per pair of poles. The winding shown in Fig. 11 has only three groups of conductors per pole pair, each group being made up of currents belonging to two different phases.

The resultant current in any one pair of bars of the 8 pole winding equals 1.73 times the current in one bar. By super-imposing Fig. 11 on Fig. 12 the resultant winding, Fig. 13, is obtained, in which the currents are of the same phase in each slot. The winding is a simple non-overlapping one.

Tests on windings of this type gave results very similar to those obtained with the single winding shown in Fig. 10. The power factor was found to be not so high as that given by the less simple forms.

The rotor windings already described are suitable for motors having one efficient speed. Motors are being manufactured which may run at two, three, or four efficient speeds, and it is clear that as these require the addition of slip-rings, the number of phases for which the rotors may be wound must be limited to two or three.

A 12-pole motor having a rotor carrying 8-pole and 4-pole windings may, if fitted with three slip-rings, be run at speeds corresponding to 12, 8, or 4 poles without losses in resistances. For a two-speed motor the connections are very simple, and especially is this the case if two rheostats are used. Fig. 14 shows diagrammatically the stator and rotor windings where the latter are of the type shown in Fig. 5.

If the motor be wound for 8 and 4 poles and the periodicity be 50 cycles per second, the two efficient synchronous speeds will be 500 and 750r.p.m. The "mesh"-connected rotor windings are wound for 4 poles and the "star" windings for 8 poles. Slip-rings are connected to the three terminals shown. The three stator terminals are connected to the mains and the tappings are coupled in pairs by three resistances. As these resistances are cut out of circuit the motor speeds up until, with the tappings short-circuited, it reaches a speed approximating to 500r.p.m. The three slip-rings are now connected through resistances, and as these are cut out of circuit the motor speed increases until it reaches 750r.p.m., with the rings short-circuited. No current now flows through the stator tappings or into the 4-pole rotor winding. The motor will give an increased output, as the iron losses are less than when cascade-connected, and the copper losses are also much reduced.

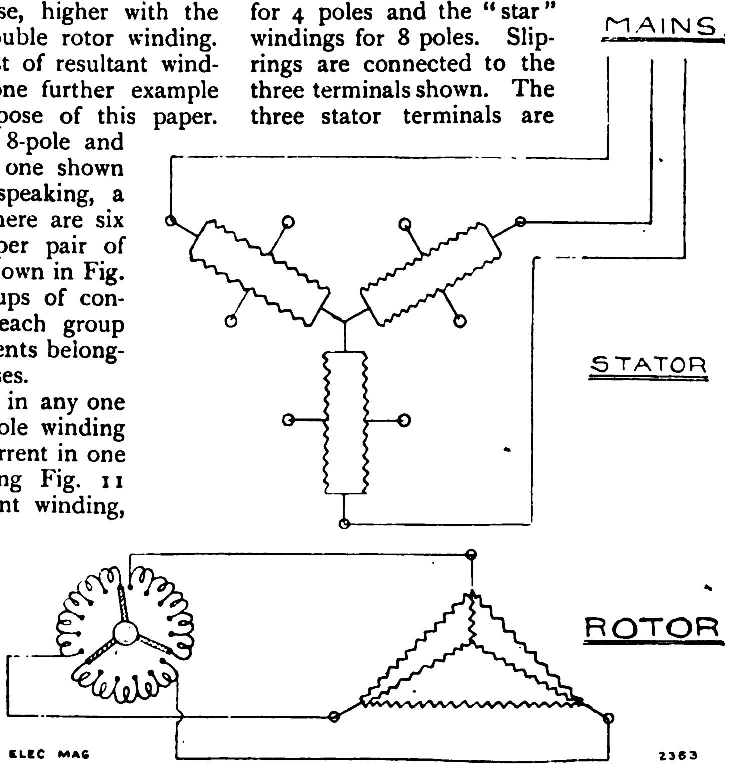

FIG. 14.

An alternative form of rotor winding is one similar to that shown in Fig. 10, but with all the slots filled with conductors. The additional bars are connected to form a "star" winding, the terminals of which are attached to slip-rings.

In order to obtain three effective speeds a change-over switch is necessary in the stator circuit. This enables the connections to be changed so that the primary currents may produce either an 8-pole or a 4-pole magnetic field. When connected for four poles, and with the slip-rings short-circuited, the motor runs at a speed of 1500r.p.m. The 8-pole rotor winding is now inoperative.

By the use of five slip-rings, the rotor connections may be changed so that both magnetic fields rotate in the same direction. The motor then runs at a speed corresponding to that of a machine wound for a number of poles equal to the difference between the numbers of poles of the two magnetic fields. For example, if the motor be wound for 12 and 8 poles, and used on a 50-cycle circuit, the following speeds can be obtained :—300, 500, 750, and 1500r.p.m.

If continuous, as well as alternating currents, be supplied to the stator windings, the motor runs at synchronous speed. The continuous-current leads may be taken to the tappings of one of the phases of the winding, or a parallel star winding may be used. In the latter case the continuous-current leads would be connected to the two neutral points of the "stars." The machine is started up as an induction motor, and when it has reached normal speed the continuous-current switch is closed. The motor pulls into step, no synchronising gear being necessary. There is no difficulty in starting against load.

The author exhibited a small 12-pole one-speed motor, the magnetic fields being 8 and 4 pole. It had a capacity of 12.5b.h.p. at a speed of 490r.p.m. when supplied with 50-cycle current. The outside diameter of the rotor was 14in. and the stator had 72 slots. There were consequently three slots, and six slots per pole per phase in the 8-pole and 4-pole parts of the machine respectively. The stator winding was of the type shown in Fig. 2, and the starting switch was arranged for two-phase currents. The rotor carried a twelve-phase winding, and there were equal numbers of 8-pole and 4-pole bars. The 4-pole conductors were connected to form two "mesh" windings. To the junction of each pair of 4-pole bars was connected an 8-pole bar, and alternate bars were connected to the "mesh" windings at opposite ends of the rotor. At each end of the rotor was a short-circuiting ring, to which alternate 8-pole bars were attached. The 8-pole conductors were consequently "star"-connected, and the ratio between the currents in the 8-pole and 4-pole bars was therefore approximately 2 : 1. The winding was similar to that shown in Figs. 6 and 7, but was twelve instead of six-phase. The author was unable in this paper to put forward test figures of these new motors, but several machines are nearing completion, and results of tests will shortly be published in the technical press.

The Sandycroft Foundry Company, Ltd., are the only manufacturers of the "Hunt" induction motor, which is described fully in the above paper. This machine is admirably suited to, and has been designed especially for, mining and colliery work; its principal feature is that it behaves exactly like a slip-ring motor and yet has no slip-rings, the rotor winding being of the short-circuited type. It starts against full-load torque taking full-load current, and against a greater torque with a proportionate increase in current. The speed can be regulated from a mere crawl to full speed. The addition of three slip-rings to the rotor gives a two-speed motor, with high efficiency at both speeds. Such a machine will start against twice full-load torque, taking only 1.4 times full-load current, and a very efficient speed-control is obtainable. The addition of a change-over switch in the stator-circuit gives a three-speed motor and a still more efficient speed-control is obtained. These motors are now being put on the market, and will doubtless meet with very great appreciation for all power purposes where alternating currents are available.

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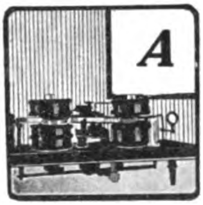
Electric Steel.



A PAPER was recently read before the Verein Deutscher Eisenhüttenlente, by Mr. H. Roechling, on the induction furnace. The following notes are from a translation which appeared in a recent number of *Electrochemical and Metallurgical Industry*.

Induction furnaces have certain characteristic features. First, there are no electrodes. Second, liquid rather than solid charges should be treated. Third, the heat is produced in the metallic bath rather than in the slag; if a specially high temperature of the slag is required, special devices must be used.

It has long been recognised that there is considerable difficulty in charging and discharging the narrow annular crucible of an induction furnace. Kjellin in Gysinge uses two tapping holes. But this has disadvantages. To overcome them the furnace used at Voelklingen is built as a tilting furnace as shown in the illustration. The furnace is suspended on two trunnions, so that by raising the back, the mouth is lowered, and the furnace can be discharged entirely.

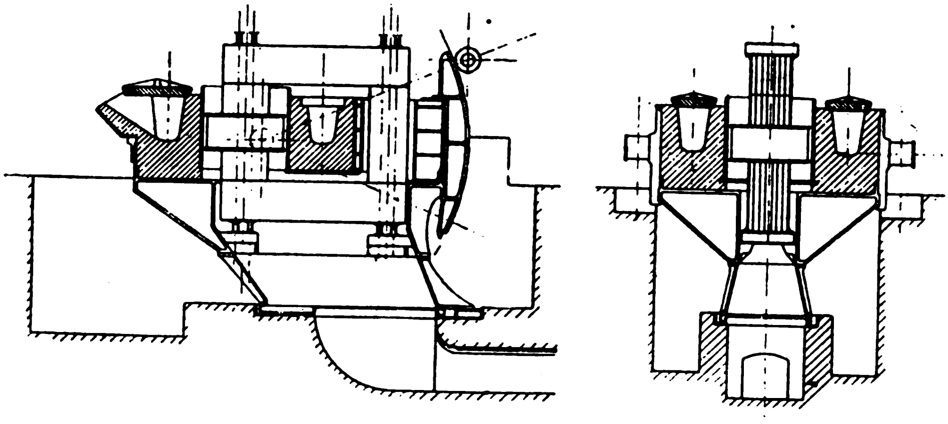
In the induction furnace, like any other properly designed electric furnace, it is possible to remove sulphur and phosphorus to mere traces (some analyses of steel produced by the author show 0.02 or 0.03 or less per cent. of phosphorus and sulphur). At a high temperature it is possible to maintain a liquid lime slag, almost free from oxide, upon and in most intimate contact with the steel bath. This has a strong desulphurizing effect. The author claims that manufacturers using electrode furnaces add considerable quantities of fluorspar to their lime slag in order to desulphurize the bath. He says that this has not been necessary in his own experiments with the induction furnace. Even without such an addition the slag was sufficiently fluid.

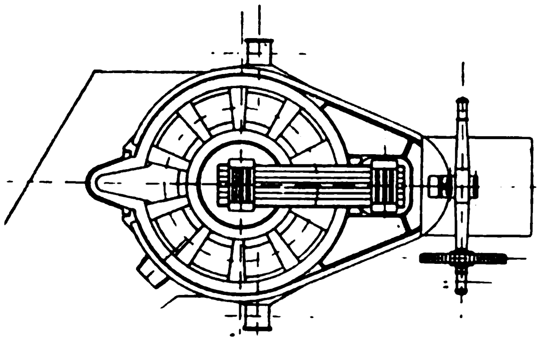
The removal of large quantities of carbon is difficult if simultaneously large quantities of phosphorus are present. The less the quantity of phosphorus in the iron the easier it is to remove the carbon. With 0.1 per cent. of phosphorus there is no difficulty. It is similar with manganese and silicon.

With respect to the deoxidation of the bath, this is not possible if the slag contains any appreciable amount of compounds of iron and oxygen. Such a slag must therefore be removed. At Voelklingen, powdered lime is then simply added to the bath to form a new slag. If necessary, this is repeated with simultaneous addition of reducing agents, and a complete deoxidation is obtained.

The experiments in Voelklingen were made with two furnaces, one containing 50kg. to 60kg. (110lb. to 130lb.), and the other 300kg. (660lb.) Alternating current of 50 periods was used. With the smaller furnace the power factor was very satisfactory; the figure given is 0.95. For the larger furnace no figure is given; it is said that the power factor is poor, but it is hoped to improve matters.

To melt pig iron and heat it to about 1200deg. C. (about 2200deg. F.), about 385kw. hours per ton were required in the 300kg. furnace. To complete a charge of scrap, about 600kw. hours are required.





Electric Induction Tilting Furnace.

The cost of this amount of electrical energy would be too high to render the process economical, and this is the reason why molten metal (instead of cold scrap, &c.), should be charged into the furnace, since in this way a considerable amount of electrical energy may be saved.

By starting with molten Thomas steel or Martin steel, it is possible to refine the bath with a low expenditure of energy. For instance, at Voelklingen it has been found repeatedly possible to completely deoxidize ordinary molten Thomas steel and to remove sulphur and phosphorus down to mere traces, and to recarburize the metal to 1 or 1½ per cent. of carbon and to finish the charge, with the total expenditure of 150kw. to 200kw. hours per ton. With this expenditure, it was possible to produce the finest sorts of crucible steel. If it is considered that this is possible with a furnace which contains only 300kg. (660lb.), it is evident that with a larger furnace much better results may be obtained. "The future of the electric furnace, therefore, does not rest in melting cold charges and replacing our ordinary metallurgical processes, but the electric furnace should be used rather as a supplement to our old processes in order to enable any steel plant to produce the finest qualities of steel from open-hearth steel at comparatively small costs."

To reduce the power consumption, two means are available. Either the size of the furnace is increased, to reduce the losses, or the metallurgical process is carried out as quickly as possible, since then the heat loss per unit of output will also be reduced.

This paper and another one by Prof. Eichhoff on the Héroult process were discussed together. Dr. Hans Goldschmidt gave some notes on the Stassano arc furnace. Stassano does not make at present steel from ore, but simply refines steel scrap. A revolving furnace of 1000h.p. is to be started very soon. An illustrated description of the Stassano furnace appeared in The Electrical Magazine, October, 1906

Notes on Celluloid.

Some useful information concerning the nature and use of celluloid appears in the current number of the *Electric Accumulator*, from which the following is abstracted:

Celluloid is made by treating cellulose ($C_6H_{10}O_5$) with sulphuric acid to which certain proportions of camphor and alcohol have been added. Cellulose constitutes the main fabric of the solid framework of plants: in the first stages of plant life the cell walls entirely consist. of it, but as the plant matures or the tree grows various colouring matters and alien impurities are introduced. The pith of the rice paper plant, the seed sperms of certain plants such as date trees, dragon trees or vegetable ivory, consist entirely of cellulose.

A ready way of preparing cellulose in a pure state is to wash white cotton, unsized paper, or elder tree pith with a heated solution of caustic soda, then with cold dilute hydrochloric acid, then with ammonia, taking the precaution to well wash with distilled water after the application of each reagent, and lastly digest with alcohol. Cellulose obtained in this manner is white, translucent, the Sp. G. is 1.5 and it is insoluble in water or alcohol.

In the manufacture of celluloid, the cellulose is treated with a mixture of sulphuric acid (Sp. G. 1.8) five parts, and nitric acid (Sp. G. 1.4) one part; in a short time we get a product termed nitro-cellulose, the acid is allowed to drain away and the mass to become hard and dry; this is then ground and well washed with water to remove the nitric and sulphuric acids, and is then treated to remove the water.

The powder is mixed with certain solvents until it becomes plastic, so that it can be rolled into sheets, and to preserve it from splitting or cracking certain proportions of oil of camphor are added. One of the earliest solvents used was naphtha distilled over chloride of lime, but it was found that this was too volatile. As a rule, glacial acetic acid is now used, and lends itself readily to safe working.

In one of the latest patent processes the nitro-cellulose, solvent, oil and camphor are treated in a cylindrical vessel; when properly mixed and pressed together the mass is subjected to hydraulic pressure and pressed through a fine gauze sieve. The result is a semi-solid mass of celluloid; this is passed to a vessel and well washed and beaten in the proportion of 4lb. of celluloid to 1 gallon of liquid, the curd is pressed to expel the water and then rolled between heated rollers on which steam is played; it is at this stage that the colouring matter is added, usually aniline dyes.

Celluloid is highly inflammable but not explosive, is workable at 125deg. (257deg. F.), and decomposes at 140deg. (284deg. F.).

In ignition cells it is not politic to use a stronger electrolyte than the commercial 1.200, this being as pure as possible and *specially* free from copper. When charging, note should be taken of the temperature, which should never be allowed to reach more than 65deg. F., or certain complex reactions take place which do not improve or extend the after life of the accumulator.

New celluloid accumulators should be stored, if possible, in a temperature of 55deg. F., and if put out of commission the ordinary storing precautions taken, and the whole cell placed in a tin biscuit box and put in a cool place.

Distilled water should on no account be allowed to remain in a cell for any length of time.

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Contributions to the Study of Strong Electrolytes.*

A. C. C. CUMMING.

THE *Elimination of Potential Due to Liquid Contact.*—Certain solutions have the property of reducing the potential due to the contact of two solutions, and potassium chloride has been used for this purpose. In most cases a saturated solution of potassium chloride does not remove all the diffusion potential; indeed, if the solutions in the cells be strong, it only removes a small part. This property of removing more or less of the diffusion potential depends on two factors in the connecting solution: firstly, the positive and negative ions must be of equal velocity; and secondly, the concentration of the connecting solution must be high compared wih the solution in the cells.

The author suggests a saturated ammonium nitrate solution as that which fulfils these two conditions better than anything else at present known, and shows by experiments with different cells that this is the case.

A curious point was noticed when two cells containing the same solution, but at different concentrations, were joined by a third solution of the same substance. Whatever the strength of this third solution, the observed potential remained the same as when the two cells were directly connected with one another. This has not been recorded before, but could have been predicted from Nernst's theory.

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* Abstract of Paper read before the Faraday Society, December 11th, 1906.

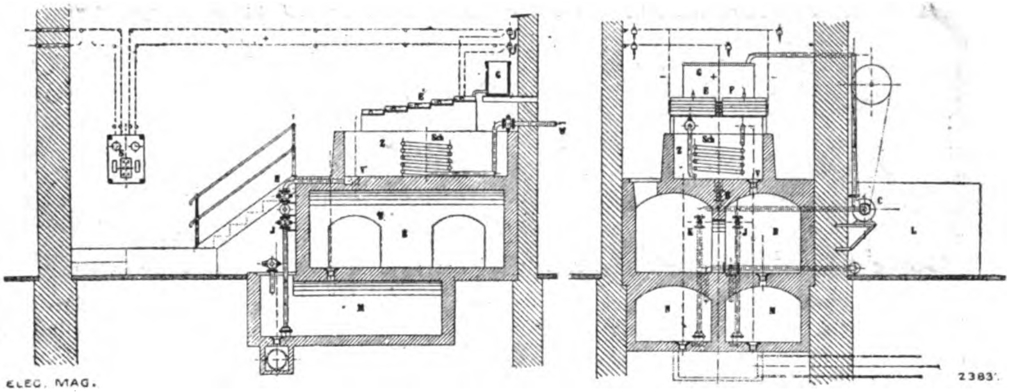


FIG. 1. ELECTROLYTIC HYPOCHLORITE PLANT.

Bleaching Liquors.

At the Bavarian Jubilee Exhibition in Nuremberg last year an electrolytic plant for producing hypochlorites, according to the patents of Schoop, was shown in operation. It is described by A. Hundt in *Elektrotechnische Zeitschrift*, Dec. 27, 1906. The illustrations show the general arrangement of the plant.

The electrolyzer E, Fig. 1, consists of ten shallow vulcanite boxes, which are placed in pairs of two on a stairway of five steps. The boxes are divided by means of insulating walls into a number of channels, about 1.5cm. broad, through which a 10 per cent. solution of sodium chloride is passed.

The solution passes from the distributing vessel G into the upper boxes and flows gradually downwards and from the lowest ones into the concrete tank Z. While the salt solution is run in that way through the boxes, it is electrolyzed. For this purpose the boxes are provided with electrodes which connect the different channels with each other and with the terminals for the supply current.

In order to get a high concentration of bleaching liquor the electrolyte is passed several times through the boxes. The pump C lifts the solution from the tank Z back into the vessel G, from where it passes again through the boxes. At the same time, the solution is cooled artificially by means of the cooling coil *Sch.* from the cold-water reservoir W. When the electrolysis is completed, the valve V is opened and the liquor passes into the storage tank B. It is then diluted with eight or ten times its volume of water before it can be used for bleaching.

The operation of the plant is as follows: The solution of sodium chloride is prepared in the solution tank L, and is then passed into the settling tanks M N, and from there, after the spigots K and J have been opened, it is lifted by the pump C into the tank G, from whence it flows through the boxes E into a tank Z. As soon as the latter is filled, the spigot H is opened and the spigots K and J are closed and the direct-current circuit is closed.

The apparatus is generally designed for 110 volts. The electrodes are either made of platinum-iridium for both poles, or platinum-iridium is used only for the anodes and graphite for the cathodes. The first arrangement, which is shown in Fig. 2, has the advantage of less consumption of current, but is more expensive and is more sensitive with respect to variations of temperature, since the temperature of the electrolyte must be maintained constant at 15deg. C. The apparatus produces about 0.2kg. of bleaching chlorine per kw.-hour, with a consumption of about 1.25kg. of common salt. Electrolytic bleaching liquor can be stored for several days without losing its bleaching activity.

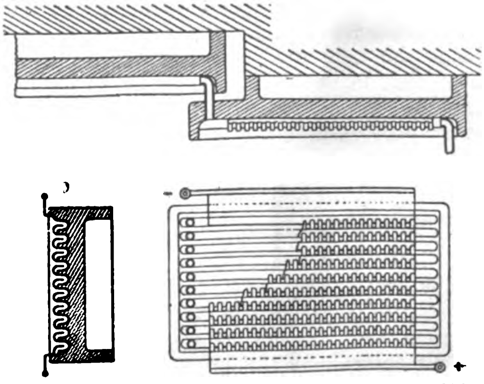
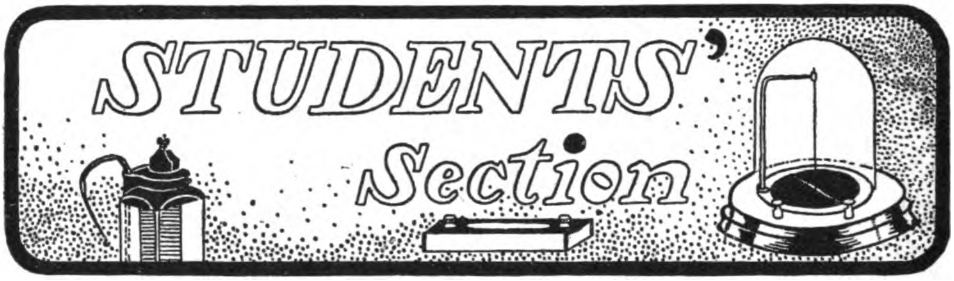


FIG. 2. ARRANGEMENT OF ELECTRODES.

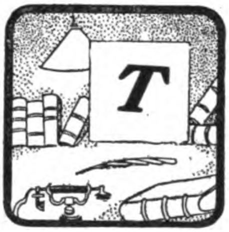


STUDENTS' Section

Students should refer to the World's Electrical Literature Section for classified list of articles of special interest to them.

A Self-Regulating Brake.

H. M. SCHEIBE.



THE inconvenience and uncertainty involved in hand regulation of the common prony brake has led to the development of a simple automatic device that is well adapted to motor loading and especially for motors of small power.

The scheme of loading is a familiar one and is shown diagrammatically in Fig. 1. The equal weights W_1 and W_2 supply the tension that makes the strap grip the pulley, and the torque thus developed is balanced by the weight W_3. The automatic feature of the device consists in the special construction of the strap used. It may be made of any flexible material with a good friction surface, but from its centre to one end it should be provided with a flexible metallic surface on the side that is to face the pulley. Such a strap may be readily made from a piece of leather belting studded with copper rivets as indicated in Fig. 2. For accuracy at light loads the belt must be quite flexible. The operation of the device is apparent from the sketch. W_3 is placed on the end of the strap provided with the metal surface and hung from the rising side of the brake pulley. If the torque developed overbalances W_3 this weight will rise and the strap shift on the pulley, until more copper and less leather are in contact with the pulley rim. This lowers the average coefficient of friction to a point that will just balance W_3, so that the amount of this weight determines the torque to which the brake will adjust itself. The difference in the friction co-efficients of leather and copper is so large that a wide range of torque may be obtained without changing W_1 and W_2.

For example, in one test with a 1in. strap on a 4in. pulley, with W_1 and W_2 each one-half pound weights, it was found that on changing W_3 from one-half to five pounds the belt moved only about 2½in. This was a ratio of one to ten, which is amply wide for ordinary purposes, as the usual range in shop testing of motors is from one-fourth to one and one-half full-load, or one to six. In the case cited the brake could have handled almost twice the maximum load given had not the motor "pulled out." By changing W_1 and W_2 the range can be extended still further, thus giving the brake a very flexible capacity.

The automatic feature of this device takes care of all changes in the friction surface due to variable temperature and other causes. This fact was quite effectively demonstrated in a test on an experimental brake in which oil was applied to the brake pulley while running. The oil simply caused the belt to

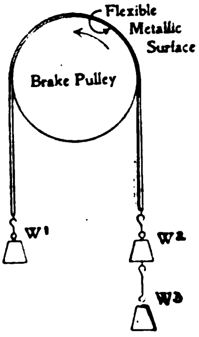


FIG. 1

ELEC. MAG.

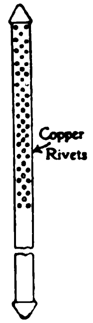


FIG. 2

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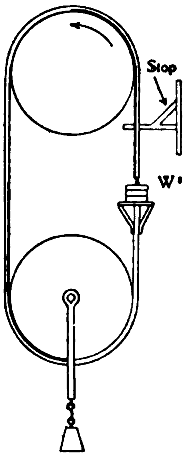

FIG. 3

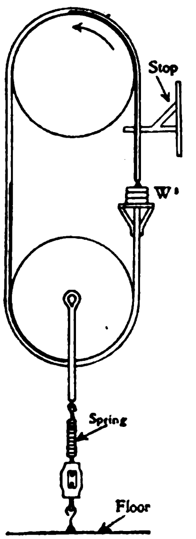

FIG. 4

ELEC MAG. 2348

shift to a new position, where it continued to operate as before.

For very accurate work on small motors it may be worth while to balance the strap by making it a continuous belt with two "rivet patches" so placed as to balance each other. In this case the weights W_1 and W_2 may be replaced by a light pulley carried in the lower loops of the belt and the desired tension obtained by a single weight or by a spring or other mechanical take-up as shown in Figs. 3 and 4.

In ordinary work, however, the simpler scheme first described will be sufficient.

In figuring results it must be remembered that the brake arm is not the radius of the brake pulley, but exceeds this by one-half the thickness of the belt.—*Electric Journal.*

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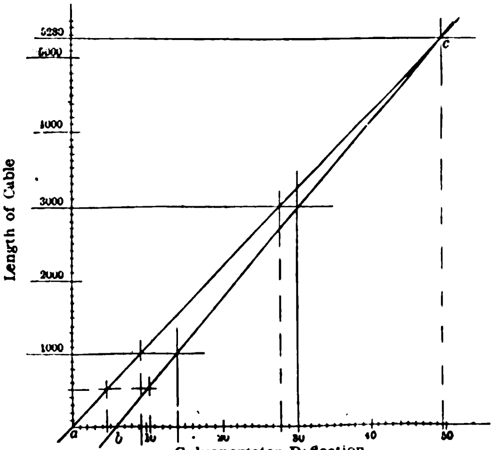
Measurement of Wire and Cable Insulation.

F. WACHTER.

The insulation of a length of wire, say, 500ft., is tested for dielectric resistance by comparison with a known resistance by means of the familiar direct-deflection (galvanometer) method, and it is assumed that the insulation resistance varies inversely with the length, because the conductivity of the dielectric is evidently directly proportional to the cross section, which varies directly with the length. Although the proportionality between the conductivity and the length is correct, it does not follow that the galvanometer deflections obtained from 500ft. and from one mile of wire, applying the same voltage in each case, follow a direct ratio.

Distributed throughout the dielectric are minute particles or pores, which form paths of relatively high conductivity for the current when the electromotive force is greater than a certain value. These particles or pores are of various sizes and shapes, and all of them have not the same resistances. There are evidently more leakage paths in a long piece of wire than in a short one. Since a drop in the electromotive force accompanies a flow of the leakage current, the terminal e.m.f. will be less than the impressed e.m.f., and it may be much less for a great length of wire than for a short piece. The dielectric strength of some of these particles or pores is large enough to withstand any electromotive force lower than the impressed value. It follows, therefore, that in a long piece of wire some of the leakage paths allow current to pass, while others towards the extreme end of the wire may not be subjected to sufficient e.m.f. to cause current to flow.

Assume, for illustration, that a coil of wire 3000ft. long gives a galvanometer deflection which indicates an insulation resistance of approximately 852 megohms per mile. When this coil is divided into three equal parts, and the parts are separately tested, it will seldom be found that the galvanometer



ELEC. MAG. 2370

INSULATION TESTS.

deflections will be the same for all coils, but their average should indicate an insulation resistance of 852 megohms per mile. Such is not the case, however, because the actual deflections will show a value of approximately 608 megohms per mile. A coil of the same wire 500ft. long will show an apparent insulation resistance of 387 megohms per mile, while a test of a continuous mile of the wire would show an insulation resistance of 932 megohms, which obviously is the correct value when the mile is taken as the unit. In the accompanying illustration, in which the vertical scale represents the length of the wire and the horizontal the galvanometer deflections, the line *ac* shows the deflections which should be obtained if they were always proportional to the length. The line *bc* indicates the deflections actually observed in the particular case chosen.

The divergence between the observed values and the correct values varies with different kinds of insulating compound. It might be stated that the more nearly the lines *ac* and *bc* coincide the better the insulating compound. As indicated by the diagram, the error is larger in a short piece of wire than in a long one; hence a short length of wire should not be selected for testing purposes.

The significance of the above results will be appreciated when it is known that a manufacturer who accepts an order for insulated wire to be delivered in 500ft. coils, each of which is to have an insulation equivalent to 500 megohms per mile, must use a higher grade of material than the manufacturer who is required to supply the wire in 1000ft. lengths, having an insulation resistance of 500 megohms per mile.

There are two possible methods of arriving at the correct insulation resistance per mile of a certain wire or cable. One of these is to test a full mile of the wire, and the other is to take readings on two or more different lengths and then proceed according to the method outlined below. Referring now to the accompanying illustration, assume, for instance, that for a wire 3000ft. long there is obtained a galvanometer deflection of 30 divisions, and from a piece of the same wire 1000ft. long the deflection is 14 divisions. It will be noted that a change of 2000ft. in the length of the wire made a difference of 16 in the deflections, so that by direct proportionality it is found that a change of 4280ft. would make a difference of 34.24 divisions, and a total deflection of 48.24 divisions would be obtained for 5280ft., or one mile, of the wire. A similar method can be employed for other lengths or other observed deflections. The problem can also be solved most readily by means of a graphical diagram similar to that shown herewith.—*Electrical World.*

The Training of Skilled Workmen.

With a view to the possibility of supplying recruits for engineering and attracting a class of well-educated youths, giving them a chance at least of finding out their ability or tastes for mechanics, Mr. Joseph Dove-Smith, managing-director of Standard Bearings, Ltd., Niagara Falls, Ont., has arranged with the authorities of the Collegiate Institute there to include a course in their factory as part of the curriculum of the young men in attendance. The plan has been entered into heartily and taken up enthusiastically by teachers and pupils alike with such success that the school authorities of neighbouring districts are negotiating for the same privilege. For one day or part of a day a week the scholars, who are grouped in divisions depending upon the size of the class, become, according to the day allotted for the various groups, part of the organization of Standard Bearings. They enter at the regular hour, punch the time clock in the same manner as the other workmen, conform to all the rules of the factory and are under the direct supervision of the foreman of the department in which they may be engaged. It is such an entire change from the humdrum of study that the work is entered into with a zest and vigour such as has not in the past been characteristic of the average apprentice. Their enthusiasm and willingness seem spontaneous, giving greater chance for development of latent mechanical talent. Many will find their interest increasing to such an extent that on leaving school they will be glad to follow up the work begun under auspicious circumstances and become producers in the industrial world. While at present in an experimental stage, the idea is worth further consideration on the part of manufacturers in other places.

The subject was taken up in a paper read before the American Society of Mechanical

Engineers by Mr. M. W. Alexander that brought forth a wide discussion, showing the general interest taken in the question. It was pointed out by President Fred W. Taylor that no country can hope to hold its own in the severe industrial competition which is to come unless the rank and file of its artisans and mechanics are educated as well as quick-witted.

I do not, of course, refer to a classical or even scientific education. I mean a thorough grounding in the principles and rudiments of the trades at which they are working. In giving this type of education to their workers I believe that the Germans are in a fair way to outstrip us, unless we become fully alive to the necessity for this work and active in its acomplishment. There are many different forces and potential elements in this country which might and should be directed towards the attainment of this object. I am looking forward to the time when our trades unions shall be a much more useful element both to themselves and to the whole community than they have been in the past; when they shall be imbued with the spirit of helping their members as well as their employers through the arts of peace rather than the arts of war; when their chief thought may be that of educating and improving their members, and thus rendering them worthy of higher wages, rather than that of devising ways for forcing their employers to make concessions to them. I think the time will come when they will realise that the true and permanent road towards high wages and prosperity lies in so educating themselves as to be able and willing to do more work in return for larger pay, rather than in fighting to do less work for the same pay or the same work for larger pay. However, I feel that we employers as a class need quite as much enlightenment in this respect as do the working classes, and that we should be brought to realize thoroughly that not only our personal interest but our duty lies in helping to educate our employés so as to be fit for a higher wage, and then in establishing such conditions as will enable them to get it. The broad-minded policy adopted by several of our larger companies, as for example the General Electric Company, in establishing systems for educating their apprentices, is to be highly commended. And I trust that all of our larger companies may in the near future follow their examples.

There are some advantages in the plan described by Mr. Alexander of having apprentices taught in a department by themselves. But this plan is to my mind accompanied by the serious disadvantage that they are not surrounded by mature workmen. They are in competition with boys instead of men, and for this reason lack the most important object-lesson of seeing skilful men working earnestly not only to do it well, but to do it quickly.

I wish to call attention to a method by which not only apprentices but also those intelligent workmen who have not been so fortunate when young as to have the opportunity of serving an apprenticeship can be taught a trade.

In the paper on "Shop Management," read before this society (The American Society of Mechanical Engineers) in 1903, forming part of Volume 24 of the Transactions, will be found a description of functional or divided foremanship, under which each workman has eight daily foremen over him instead of one.

Each of these foremen devotes his energies to one-eighth only of the work in which the ordinary foreman is supposed to be proficient, and as a consequence acquires a competence in his specialty far in excess of that possible to the old-fashioned, all-round man. Under this system these functional foremen are called upon not only to teach but to stand over and train the men under them into a knowledge of how to do their work and also to manual dexterity. The rapidity with which the workmen and apprentices learn under this constant supervision and help is indeed remarkable, and as this system can be established in small shops as well as large, with great profit both to employers and employés, it offers a ready solution to the problem of educating our apprentices.

The subject was then taken up by Mr. H. K. Hathaway, who said that the shortage of efficient workmen is a problem of such vital importance that unless more attention is given to its solution the expansion and development that the industries have enjoyed must inevitably be greatly restricted.

Mr. Alexander (the author of the paper under discussion) has pointed out one way to overcome this unfortunate condition, in his description of the training shop for apprentices maintained by the General Electric Company, and it is with great satisfaction that I note that the scale of wages paid is about 50 per cent. higher than are ordinarily paid apprentices, and this alone, if generally adopted, would do much to overcome the disinclination that most boys and young men have to serve an apprenticeship. I believe that still better results would be achieved if the wages paid started at about $8 per week and went up by easy stages to $12 per week for the final period. If this were done it would enable many young men between the ages of twenty and twenty-five years who are entirely dependent upon themselves for support to enter the field of mechanics, and such young men would prove of far greater worth, both during their apprenticeship and afterwards, than boys from sixteen to twenty years old. Furthermore, the shorter hours, clean hands, and $8 per week of the clerk would not appear to such marked advantage over an apprenticeship to the machinist trade. The trade schools offer a partial solution to this problem, but there are so few of them and the number of students in each is so limited that very little practical benefit can be looked for from that quarter, unless we can have many more of them. The training shop of the General Electric Company bears a strong resemblance to the trade school, and from the fact that it is in close touch with great manufacturing works, has many advantages over the trade school, and is infinitely superior to the haphazard instruction that is characteristic of the average apprenticeship. Unfortunately, however, the training shop plan is entirely out of the question for the average small manufacturing plant. Mr. Taylor's plan of functional foremanship seems to offer the best solution to the problem of supplying the demand for efficient workmen, and I believe that if it were applied in the General Electric Company's training shop, the good work being done there would be greatly enhanced, the instruction made much more thorough and accomplished in a much shorter time.

From my experience thus far, I firmly believe it is possible, under the system of functional foremanship, to turn out in two years an all-round mechanic who is in all respects a more efficient workman than is ordinarily turned out in four years under the old system, and at practically all times during this period of training to get practically the maximum efficiency from each man by reason of the constant and thorough nature of the instruction and help received at the hands of the various functional foremen, while the wages paid are so high as to attract mature men rather than immature and unsettled boys.

It has always seemed to me the height of unfairness to withhold from deserving men the privilege of bettering their condition by learning a trade, and to restrict this privilege to boys alone, who seldom fully appreciate it. This state of affairs is probably due to the fact that under the usual system of management an apprentice is considered an expense item for a large portion of his time and is consequently paid low wages and expected to accept the experience and instruction he receives, in greater part as compensation for the period when his services are profitable to his employers.

Mr. L. D. Burlingame expressed hearty agreement with any plan that would help towards the adoption and development of the modern apprenticeship system.

From my experience I can see the importance of a system for training men to develop skill. It has been for many years our plan (The Brown & Sharpe Manufacturing Company) to give such training. I am glad to see that not only individual manufacturers throughout the country are taking up this matter of apprenticeship, but that organizations such as the Manufacturers' Association, that are interested in the development of mechanical industries, are also taking action in a way that will help to spread and develope such a system. We consider it is best to have the boys mixed in with the other men from the beginning; whether it be pattern-makers, machinists, or draftsmen apprentices, we have them acquire their knowledge by such contact throughout the time of their apprenticeship. One point criticised is that one boy is allowed to teach another from step to step. I consider this an advantage, as it trains the boy who is acting as instructor as well as the boy being instructed, and if this is done under a competent supervisor, he will see that a high standard is maintained.

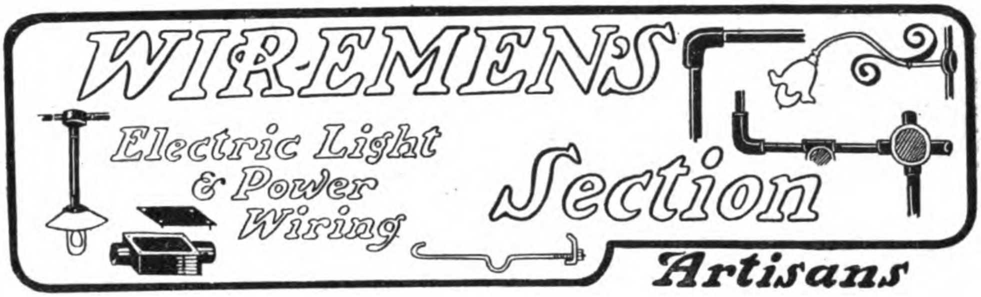
No greater problem is presented to manufacturers and superintendents to-day, said Mr. C. F. MacGill, than that of supplying the required number of skilled workmen. The plan under discussion furnishes, it seems to me, the best solution of the problem.

I visited the apprentices' department of the Lynn Works and found that the instruction given was very thorough and systematic, and of such a nature that in a remarkably short time the boys could be depended upon to do good commercial work.

In the primary training department work was done involving the simpler operations of drilling, boring, turning, balancing, &c., most of the work being on small cast-iron pulleys. In the secondary or advanced training department, a really high grade of work was being done, turning armature shafts to a limit of one-half-thousandth of an inch, making jigs and fixtures for use not only in the training departments, but throughout the works. I then went through some of the machine departments, where regular production work is done, and found the apprentices on that class of work for which it has been my aim for some years to train them.

I was particularly pleased with what I saw of their work in the steam turbine department at the River works. One apprentice in the fourth year of his course was running a ten-foot vertical boring mill; others were working on large planers, milling machines, &c. It was very evident, from the speeds and feeds used, that their training had been very thorough, and was producing good results. I cannot speak of the schools, as I was there in the summer, when they were not in session.

The impression seems to prevail among a number of engineers and educators that it is not necessary for an engineer or designer to be able to perform all of the operations involved in machine work, if he understands the underlying principles. I think this idea has done and will do a great deal of harm. The man who cannot do a given piece of work does not really understand how to do it.—*Canadian Manufacturer.*



Wiremen and Artisans should refer to the World's Electrical Literature Section for classified list of articles on subjects of importance to themselves.

Conduit Work in Fireproof Buildings.

T. W. POPPE.

When running main-line conduits in which the feeders will be drawn, care should be taken to have all joints well made so the wire will have a clear raceway. Should burrs be allowed to remain in the conduits when screwed together they will retard the insertion of the wire and perhaps damage the insulation. Particular care should be taken with feeders in this respect, as insulation so damaged is very apt to result in a heavy ground. The resultant heat will melt the insulating compound, and the wire, which will necessarily have to be withdrawn from the conduit, will adhere to it at this point, and trouble will be experienced. It will also mean the loss of the wire damaged and vexatious delays.

Upright lines of conduit should be fastened in such a manner that the panel box will not be called upon to support their weight. Each length of conduit put in should be fastened separately so that the one below will not bear any of the weight of the one above. This can be done by drilling two holes in the brick wall, if the conduit runs up beside a brick wall, inserting lag screw anchors and fastening a piece of 2in by 4in. joist, as long as necessary, against the wall, using lag screws to secure it. This joist, known as a cleat, should be so placed that the bottom of the coupling on the pipe or conduit will be level with the middle of the cleat. Pipe straps can then be placed upon the conduit close up against the bottom of the coupling. Two-inch screws should be used to fasten the strap to the cleat. Pipe straps so placed will carry separately the weight of each length of conduit.

A workman should endeavour to have each length of conduit fastened separately, so that were a portion of the line removed the part above would remain in position without too great a strain being placed on the woodwork of the panel box or the thread of any elbow which might be above it.

Judgment must be used when installing the conduits. A pull-box readily accessible at all times should be conveniently placed on all lines over 100ft. long in which four elbows have been used. Elbows and bends should be avoided if possible. When running vertical lines, should the conduits be perfectly straight from bottom to top and not be connected to any horizontal line, it is proper to put in two elbows even if not necessary otherwise. The horizontal lines will thus support the cable suspended in the conduit, and in the absence of a horizontal line the friction caused by the cable pulling around the curves in the two elbows will tend to resist the downward pull due to the weight of the suspending cable. This takes all the strain off the lugs and fastenings of the panel-board.

Should the construction of the building not allow of two elbows being placed in a vertical line of conduit, some means must be taken to secure the cable and prevent the strain due to the weight of the cable upon the lugs and panel-board fastenings. The arrangement as shown in Fig. 3 has been used with success. A pull-box is placed in the wall and the conduit run to and from it.

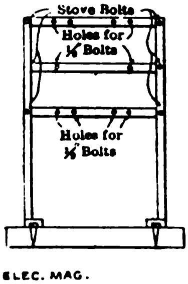


FIG. 1.

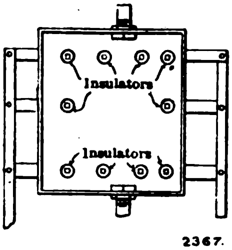


FIG. 2.

The pull box is made of oak, lined with sheet-iron, and fastened to a frame of angle-iron, as shown in Fig. 1.

In the three horizontal pieces ten ⅝in. holes are drilled as shown, and ½in. bolts 3in. long and threaded their entire length are placed through the holes. Holes to correspond are drilled in the back of the pull box and the pull box fastened to the frame by screwing nuts on the bolts firmly against the sheet-iron lining of the box. Insulators known as circuit-breaking insulators are placed over the projecting part of the bolts and firmly secured by screwing nuts on the bolts, placing a leaden washer between the nut and the insulator.

This, when finished, gives an arrangement similar to that in Fig. 2. When the cables are drawn into the conduit they are arranged as shown in Fig. 3. This holds the cable firmly in place. The plan, as shown, was used on a two-wire system, but three wires can be used by installing more insulators in the box.

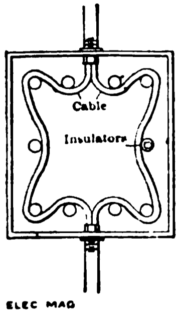


FIG. 3.

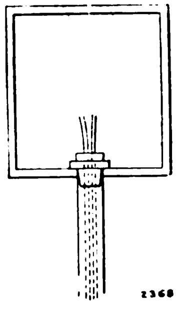


FIG. 4.

When the box is placed in position and the conduit finished, the box, conduit, and frame should be firmly cemented in the wall. When the cable is drawn in and arranged a neat wood trim made to match the surrounding woodwork can be placed on the pull box so that the box is always accessible.

The above scheme is applicable where mains are extended to a height of 80ft. or more, and should the cable be large the height of the pull box can be arranged to suit the size and weight of the cable and as many pull boxes as necessary to properly secure the cable can be put in the line. The box can be made to accommodate as many cables as desired by enlarging the box and placing heavier band or angle iron in the rear of the box.

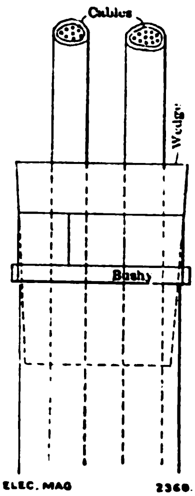


FIG. 5.

In short lines having no elbows and in slightly longer lines having two elbows a wooden wedge can be made by boring holes slightly smaller than the diameter of the cable parallel with the grain in a piece of wood of a larger size than the conduit. The wood is tapered to a size slightly smaller than the inside diameter of the conduit, and is then split through the holes bored, placed in the conduit and hammered till firmly wedged. The holes being smaller than the cable and the wedge being tapered to a size larger than the conduit, the wedge will press firmly together, holding the cable securely, and any extra weight on the cable will tend to tighten the wedge. Figs. 4 and 5 show this arrangement.
—*Electrical World.*

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MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

Dead-beat Ammeters for General Power Use.

Nalder Bros. & Thompson, Ltd.

THE illustrations herewith show a new type of ammeter which Messrs. Nalder Bros. & Thompson have recently placed upon the market. It is a small dead-beat instrument at a very reasonable price and has been introduced for widespread and general use in connection with motor installations without unduly increasing the cost of the installation. The necessity for such an instrument is obvious and only questions of cost have hitherto restricted the inclusion of an ammeter in every motor circuit.

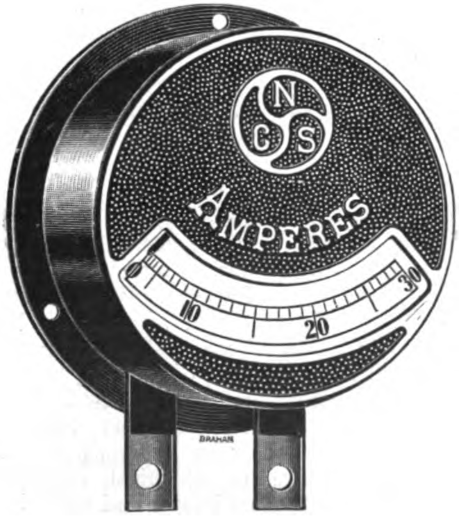


FIG. 1. NALDER AMMETER FOR FRONT CONNECTION. TERMINAL COVER REMOVED.

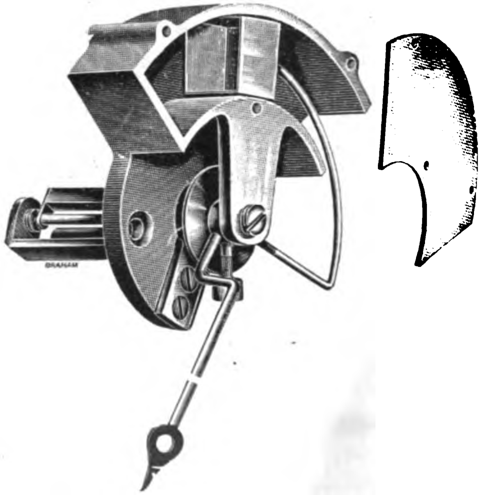


FIG. 2. INTERIOR PARTS OF NALDER AMMETER FOR POWER CIRCUITS.

These instruments are provided with two scales and are calibrated to give readings of amperes and also of horse-powers. This double graduation is now becoming usual for ammeters installed in motor circuits.

The cases of these instruments are of iron enamelled black, and the relief parts finished in nickel or copper. The base is of polished insulated material, very hard, and non-inflammable.

The instrument is made with either back or front connections, so that it can be installed conveniently without any special arrangement for connecting up being necessary. With the front-connection type the contacts are enclosed in a suitable cover of insulating material.

Fig. 1 illustrates the general appearance of the instrument, as for front connection and with the terminal cover removed; Fig. 2 shows the working parts. It will be noticed that the instrument is fitted with air damping, and it is claimed to be absolutely dead-beat. The movement being a specially designed soft-iron one, the instrument is equally suitable for either direct or alternating currents. The moving parts are enveloped in a soft-iron screen so that the instrument is unaffected by external fields.

"Kohinoor" Arc Lamps.

Union Electric Company, Ltd.

THE "Kohinoor" arc lamps were designed to supply a combination, in an artistic form, of a pure white light with economy in current, maintenance and carbon consumption, coupled with long burning hours. The illustrations herewith show the general pleasing appearance and good proportions of the lamps as for indoor and outside installation.

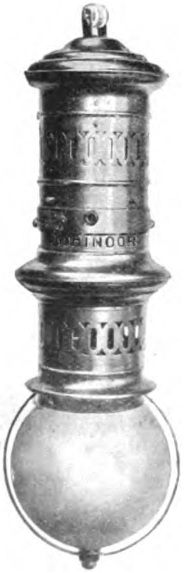


FIG. 1.
"KOHINOOR" LAMP,
INDOOR PATTERN.

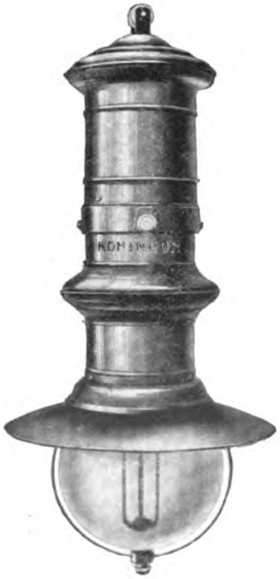


FIG. 2.
"KOHINOOR" LAMP,
OUTDOOR PATTERN.

Special features of the new lamp are that the globe is entirely and evenly illuminated, thus giving the agreeable fireball effect and softening of shadows; the efficiency is stated to be about twice that of ordinary enclosed arc lamps, enabling the same illumination, but of a better quality, to be obtained with half the capital outlay and half the expense for current; the burning hours of the carbons are exceptionally long in spite of their small diameter (6mm.), short length, and low price, one foot of carbon lasting for over thirty hours. The waste end of the upper carbon is used when trimming the lamps in place of a new lower carbon for the next period of use.

The richness of the polished gun-metal casing renders the lamp suitable for every class of interior illumination; the lacquer over the metal is one that has proved after years of trial to be thoroughly permanent and unaffected by heat and atmospheric influences. The height of the lamp is 21½in. and the diameter over the globe 7in.

In its construction all parts are standard and interchangeable, the materials are specially selected, and, with the exception of the coil windings, the insulation is of porcelain, mica, or glass; all the interior metal parts are nickel-plated.

The "Kohinoor" lamp is for direct-current circuits, burning singly on 100-120 volts, and two in series on 200-250 volts. The normal current required is 5amp. and the candle-power is stated as a maximum of 1000c.p. and a mean of 700c.p. as measured with the ordinary globe fitted.

The Use of Insulating Varnish.

Pinchin, Johnson & Co., Ltd., London.

IT is not always sufficiently well recognised that from the very day electric plant is put into service deterioration sets in. This is particularly true of the insulation of the windings of motors and generators. Perfection in insulating material, whether it be tape, fuller-board, mica, or varnish, has not up to the present time been reached. It is therefore more than necessary that the limitations of insulating materials used in the manufacture of electrical apparatus should be thoroughly known and taken into account by the users of electrical plant.

One of the most vulnerable points in a motor or generator is the insulation of the windings, because the deterioration referred to is likely to set in here with rapidity if certain precautions are not taken.

Liquid insulations, used to exclude moisture, are very largely compounded of drying oils and gums. Such combinations dry by a process of oxidation which is more or less constantly going on, very slowly indeed at the ordinary temperature of the atmosphere, but more quickly under the influence of high temperature sometimes reached by machines when in service. The product of oxidation of such compounds is hard and brittle and is liable in the presence of vibration to disintegrate, allowing moisture to enter the windings of the machine, which sooner or later will cause breakdown.

The recognition of this deteriorating property which all insulating varnishes possess to a greater or less degree, will be of great assistance to those employing electrical plant in general industries. The insulation can be almost indefinitely preserved by the periodic coating of the windings of the machines with some insulating compound which is not subject to change to the same extent as the drying oils and gum compounds referred to. Such compounds are on the market, and should be freely used on all electrical plant, particularly those machines which are to perform their duties under unfavourable climatic and general conditions. Electrical engineers in collieries would do well to see to it that the windings of their electrical apparatus are periodically protected in the manner suggested. It is just as necessary to re-varnish the windings of electrical machinery as it is to re-paint and varnish the office door.

Messrs. Pinchin, Johnson & Co., Ltd., make a speciality of insulating varnishes for all classes of electrical work. They do not claim that one grade of varnish will serve all purposes, but are experts in the compounding of insulating fluids to suit particular requirements. To demonstrate the effectiveness of their several products they are issuing periodically a little publication entitled *The Insulator*, and to the user and maker of electrical plant of any description the three numbers which have recently appeared will appeal as containing much valuable information. The insulation and preservation of cables, switch-boxes, dynamos and motors, traction equipments, &c., are all dealt with separately, and the class of varnish and the process of applying it in each instance is described in detail.

The following is an extract from one of the articles, the subject being "How to Insulate Armature Coils":—

For the insulation of direct-current motor and dynamo armature coils, it is advisable to use what is known as the "double-dipping" method, as all coils of this kind are usually former-wound, and are, therefore, readily adapted for this treatment. After the coils are formed, they are clipped together at the corners, and dipped right into the varnish compound, and then allowed to dry. When the coils are thoroughly dry, they should be taped and again dipped in the varnish compound—and dried.

To get the best results on this class of work, particularly when handled in quantities, the varnish must have great plasticity and good insulating and quick-drying properties. The varnish should also be a combined baking and air-drying varnish, as quick-drying varnish is often an absolutely necessary factor—in many cases, the varnish must be thoroughly dry from one to two hours after baking.

The varnish, which has great plasticity, is also of vital importance on this class of work, because in making up the standard types of machines, it is often desirable and economical to make up enough coils to provide for the entire output of each size machine for a long while ahead—in many cases for six months or even a whole year.

On armature coils of tramway motors, the great essential is durability and waterproofing qualities The test of time has shown that the varnish which best accomplishes the desired results is a varnish of hydro-carbon base, which dries quickly and remains indefinitely soft and plastic. This quality enables a varnish to withstand the contraction and expansion always present in a tramway motor, and prevents the breaking of the insulating film from vibration and heat, thus absolutely and indefinitely repelling moisture, which in the majority of cases is the direct cause of short circuit and burn-outs. The "double-dipping" method described above is absolutely essential in the treatment of tramway motor armature coils.

In tramway work it is also necessary that a finishing coat of varnish be given the armature after the coils are assembled, as very often injury to the insulating film results from placing the coils into the slots. This coat of varnish not only serves to remedy any defects of this nature, but also provides an additional waterproof coating to the whole armature. A varnish of this nature to be successful should have in a great degree the qualities of dipping varnish, such as ability to withstand long-continued heat and vibration without becoming brittle, and absolute water-proofing qualities.

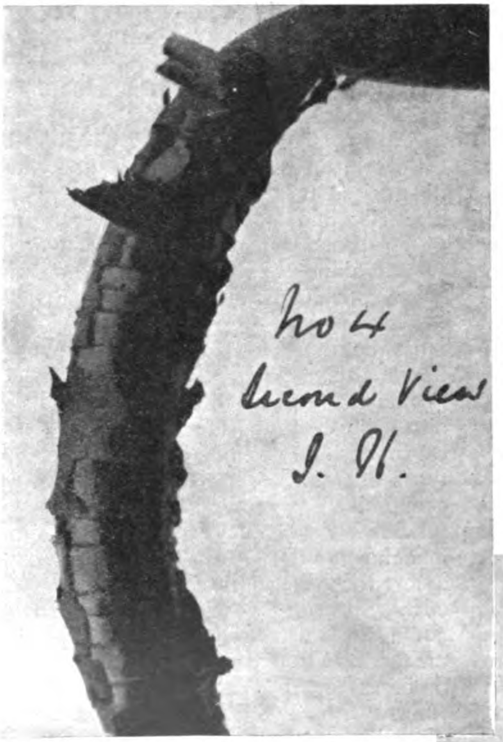


Fig 1. A Sample, not Simplex.

Wiring-Conduit Enamels.

Simplex Conduits, Ltd.

The illustrations on this and the succeeding page tell their own story as to the behaviour of conduit coverings or enamels under bending strains. The history of a severe series of competitive tests on various makes of conduits made by independent observers is set forth in a pamphlet recently published by Simplex Conduits, Ltd.

The specimens under test, ten types in all, were bought from makers' stock by an outsider, and, disguised under numbered labels, were supplied to Mr. John Hewett, B.A., M.I.E.E., consulting engineer. All chances of any than a perfectly honest and straightforward comparison were avoided. Five was the number allotted to the Simplex Conduit samples, and the illustrations and text of the published report prove that the nature of the enamel used for conduits is of great importance and that the Simplex people have apparently arrived at perfection in this.

The tests by Mr. Hewett consisted of: measurement of diameter and gauge—a micrometer gauge and standard wire gauge being employed for this; bending slowly to a 4in. radius, for which purpose a Conrex bender of standard manufacture was employed—bolted down, and the tube bent slowly by hand; a piece of conduit cut off 5ft. long—selected at random from marked bundle—the end held in an engineer's 4in. vice, and the tube slowly bent by hand to a right angle, the bend being as near 1½in. radius as practicable; a tee, from the marked bundle placed on anvil, and struck repeatedly with 3lb. hammer until deformed; tube struck with back of knife to test brittleness of enamel and its power of holding to the metal of the tube; whole sample of tube examined as

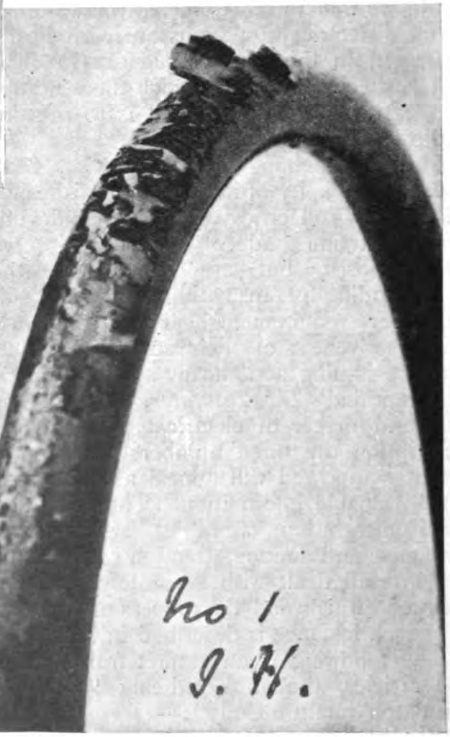


Fig. 2. Another Sample, not Simplex.

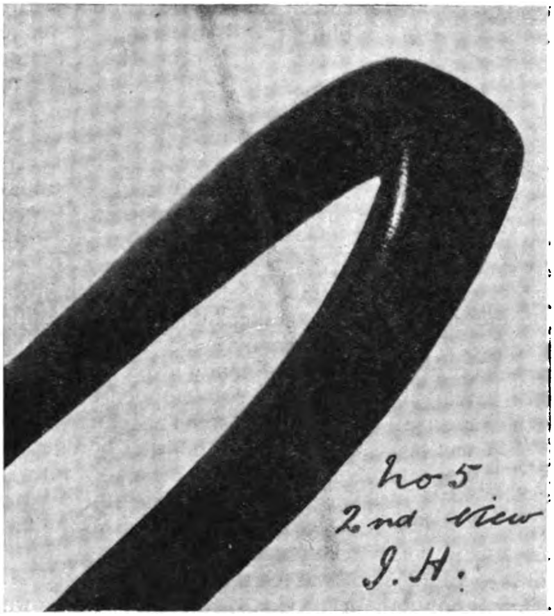


Fig. 3. A Simplex Conduit Test-piece.

received, for coating, surface, hardness and touch; and an acid test in which a straight length, and a length bent to 4in. radius—both picked at random, were plunged in a 10 per cent. solution of hydrochloric acid, drained, and exposed in the open air for seven days and nights.

It is absolutely essential that all enamel used for the covering of conduits should possess the following features: Property of adhering to the metal of the tube, flexibility, resistance to mechanical injury, resistance to action of alkalies, acids and moisture, good insulating properties, absence of any compound in the enamel itself which is injurious to the metal of the tube.

As to how far the several grades exhibit these desirable properties is told in the publication recording the above tests and also including a report by the Faraday Electrical Testing Standardising and Training Institution. All consulting engineers and wiring contractors should secure a copy of this interesting and valuable booklet.

◆

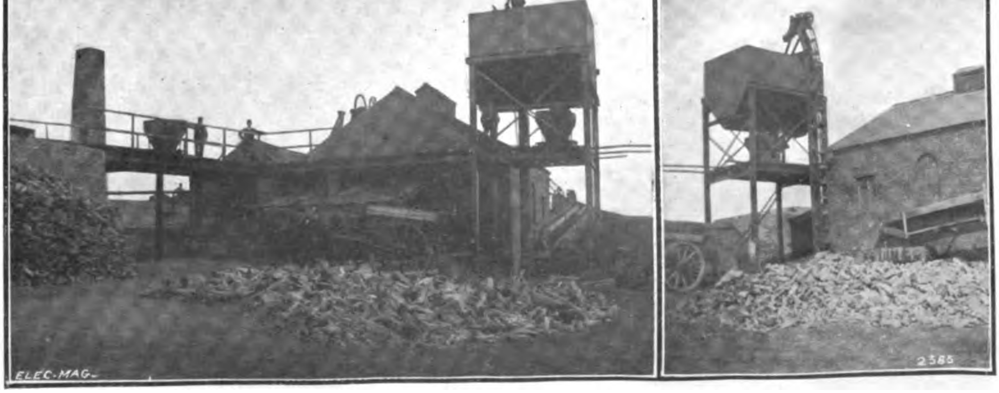
Colliery Plant.

R. H. Longbotham & Co., Ltd.

The means of coal handling at the surface which have been adopted at the Mickley Colliery, situated in one of the most picturesque districts of Derbyshire, near Dore and Totley, is shown in the illustrations, Figs. 1 and 2.

The seam worked is proving a most valuable one, producing a good coking coal, and several developments have lately been instituted in the equipment of surface plant and oven supply to obtain the best results.

As the coal is brought from the mine it is screened, and the small coal is elevated to the washery. On referring to Fig. 1 will be



Figs. 1 and 2. Modern Coal-Handling Plant at the Mickley Colliery, Derbyshire.

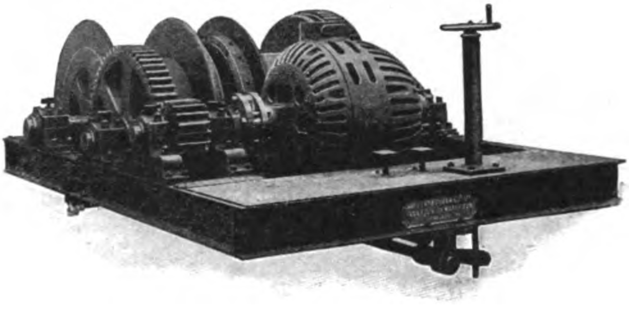


Fig. 3. Main-and-tail Electric Haulage Gear, 125h.p

seen in the distance under the large storage bunker the head of this elevator, which is of the lattice-braced type, self feeding, from the supply under the fixed screens.

After being thoroughly washed the coal is delivered into a second elevator which raises it to the large storage bunker; the form of this elevator may be more clearly seen in Fig. 2. This elevator is nearly 50ft. high, and provision has been made in the elevator pit for a disintegrator, as it is expected that the supply of small coal will shortly be insufficient for the demand. The top of the elevator is curved well over the bunker to take full advantage of its automatic storage capacity. The staging shown in Fig. 1 connects the bunker with the range of coke ovens. Each of the elevator buckets is perforated in order to assist the drainage of the water, which is further carried out in the bunker. The bunker is of steel throughout, mounted on a steel superstructure, well braced in all directions to withstand the wind pressure.

The coal is withdrawn from the bunker into the discharging hoppers by means of two sliding doors operated by hand levers, provision being made so that two hoppers may be filled at the same time. The gantry connecting the underside of the bunker to the coke ovens has been arranged with a small gradient in favour of the full tub, to equalise the force required to move the full and empty chargers.

This plant was erected by Messrs. R. H. Longbotham & Co., Ltd., the well-known mining specialists of Wakefield, who are at the present time turning out a large amount of work, including a good many haulages to their standard designs for collieries in various parts of this country and for abroad.

Fig. 3 shows one of four electric main-

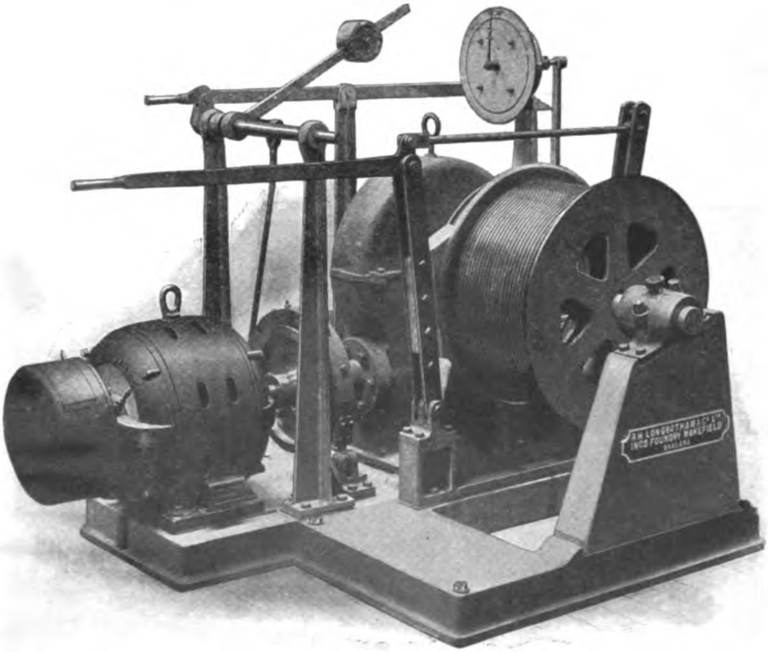


Fig. 4. A 70h.p. Electric Haulage, with Motor coupled through Worm Gearing.

and-tail haulage gears which have just been completed and are now doing useful work at a large colliery in the North of England. The gears are self-contained and consist of two drums 5ft. 6in. diameter by 2ft. wide mounted on a 7in. diameter shaft; each is provided with a powerful foot brake and a double clutch. The motion is transmitted to the shaft by a double train of spur gears from a 125b.h.p. motor, the extension shaft of which is provided with a flexible coupling and a raw hide pinion.

A special form of electric haulage gear is shown in Fig. 4. This was recently put to work at a colliery in Scotland, and consists of a winding drum 4ft. diameter, having a grooved face. The motion is transmitted from the 70b.h.p. motor through a highly finished worm and phosphor-bronze worm wheel. It is provided with an indicator, and in addition to the pillar brake it is fitted with an emergency brake operated by means of the indicator so as to prevent overwinding. This is done by means of a lever on the indicator shaft which releases the automatic brake on the motor shaft.

Messrs. Longbotham & Co., Ltd., further report that they have just put in hand eight electrically-driven sets for shipment to India in addition to a 150b.h.p. electric endless-rope haulage gear; also a pair of 15in. by 20in. engines and endless haulage and 16in. by 24in. main-and-tail steam haulage gear, besides many others of varying sizes and types.

* * *

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are recommended by the Editor of this publication to carefully study the manufacturers' announcements contained within the covers of this journal before dealing elsewhere.

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COLLIERY BOOKS.

Practical Coal Mining. BY LEADING EXPERTS IN MINING AND ENGINEERING; UNDER THE EDITORSHIP OF W. S. BOULTON, B.SC., F.G.S. (LONDON: THE ELECTRICAL PUBLISHING CO., LTD., 4 SOUTHAMPTON ROW, W.C. SIX VOLS., PRICE 6s. NET EACH VOLUME.)

The first volume of this important work is now available and suffices to show that the complete series will prove to be one of the most valuable treatises of coal mining ever produced. Volume 1 includes three and a portion of the fourth of the eighteen sections into which the contents have been divided. The sections completed are: The Geology of the Coal Measures; Composition and Analysis of Coal; Trial Borings; and the first part of Section IV., which deals with shaft-sinking. All mining men and students of engineering should secure a copy of this work, which is in every sense a remarkable book and is exceptionally cheap considering the nature of its contents and the best of printer's materials and work which has been put into it.

Modern Mining Practice. EDITED BY GEORGE MITCHESON BAILES, M.E., M.I.M.E. VOL. I. (LONDON: THE ELECTRICAL PUBLISHING CO., LTD., 4, SOUTHAMPTON ROW, W.C. TO BE COMPLETED IN 5 VOLS., PUBLISHED QUARTERLY, PRICE 10s. 6d. EACH NET.)

Judging by the first volume to hand, this is essentially a book for the mining specialist and student. Volume No. 1 consists of some 250 pages, fully illustrated, and produced in clear type, so arranged as to afford ready reference. Thus there are already seven chapters; these deal respectively with: The Chemistry and Physics of Mining; Coal-Dust, its Dangers and Treatment; Gases met with in Coal Mines; Ventilation; Direction and Distribution of the Air Current; The Friction of Air in Mine Passages; and Safety Lamps. It is promised that every phase of mining work and the very latest methods employed will enter into the series and will be treated in a descriptive, and also in a simple, scientific manner. So far the object is very well accomplished, and we can recommend the book as being exceptionally useful and pleasing in its form.

Analyses of British Coals and Coke, AND THE CHARACTERISTICS OF THE CHIEF COAL SEAMS WORKED IN THE BRITISH ISLES. WITH COMMERCIAL INDICES AND MAP. COMPILED BY ALLAN GREENWELL, F.G.S., ASSOC.M.I.C.E. (*Editor of the "Colliery Guardian"*) and J. V. ELSDEN, F.G.S., B.SC.(LOND.).

WITH AN INTRODUCTION, THE CLASSIFICATION OF COALS AND THE INTERPRETATION OF ANALYSES. BY CLARENCE A. SEYLER, B.SC.(LOND.), F.I.C. (LONDON: THE COLLIERY GUARDIAN CO., LTD., FURNIVAL STREET, E.C. PRICE 5s. NET.)

A work of reference extending to upwards of 450 pages, the contents of which are fully outlined above. The various assays and analyses are arranged in the order of districts of the several collieries. The information is well set out and will be found of great value in those industries wherein coal and coke are staple requirements—particularly in the gas-making and iron and steel industries. It is a remarkably cheap production, being excellently printed on good stout paper and well bound.

How to Become a Colliery Manager. By Henry Davies. (Wigan: Thos. Wall & Sons, Ltd. Price 2s. 6d.)

As its title would indicate, this is a book for the aspirant to a leading position in the mining industry. It is essentially for the specialist, and contains very little of interest to the general engineer. It is not a text-book, but is rather a guide to the student of mining engineering as to his method of study, the nature of the examinations, and the duties attending the appointment of colliery manager. A great feature of the work is the extensive collection of past examination questions which is included; the Board of Education and the Home Office examination papers for about twenty years past form an Appendix which in itself will be found invaluable by the student.

The Principles and Practice of Coal-Mining. By James Tonge, M.I.M.E., F.G.S. (London: Macmillan & Co., Ltd. Price 5s. net.)

The author has prepared this book especially for students—those who intend to adopt mining engineering as a profession and for those practical miners who seek to gain the Colliery Manager's Certificate. It is a useful and accurate little book, which is certain of a large sale. The various branches of the subject in theory and in practice are followed thoroughly from the most elementary stages to a position where the reader can depend upon practical acquaintance with mine operation to render him a proficient mining engineer. Of course the student will of necessity be required to take up the sciences of geology, chemistry, mechanics, &c., in more detail from other specialised works, but without previous knowledge of such sciences the book under notice can be followed with ease. In that is its great advantage—it is a capital students' book.

OF COMMERCIAL VALUE.

Atlas of the World's Commerce. By J. G. Bartholomew, F.R.G.S., F.R.S.E. (London: George Newnes, Ltd. In Fortnightly Parts, Price each 6d. net.)

We have recently received Parts 20, 21 and 22, which bring this most important publication to a conclusion. Now that it is complete we ought to call particular attention to this work, which is beyond question a most important commercial atlas. It presents, by means of clearly printed maps and charts and lucidly explained diagrams, with a wealth of detail that has never been surpassed, a complete survey of the International Commerce of to-day, and provides a key to the Merchandise of the World.

The complete Atlas consists of 176 large pages of coloured plates, containing upwards of 1000 maps and diagrams, illustrating in a most graphic fashion the distribution of the various products, the imports and exports of the various countries, also their natural resources, the means of communication and transport, and many other aspects of commerce.

This is undoubtedly a work of singular value to all students of economics, and should prove of supreme importance to everybody who is in any way interested in commerce.

The World's Commercial Products. (London: Sir Isaac Pitman & Sons, Ltd. In Fortnightly Parts, Price each 7d. net.)

Now that this work is completed, the twelfth and last part having recently appeared, we have to direct attention to the complete work, which does indeed bear out the expectations expressed in the review published in The Electrical Magazine of November last. The whole of the contents are extremely interesting, and valuable as contributing so greatly to that accurate general education which is essential to all desiring to make personal progress. Of particular use to a section of electrical engineers is an extensively illustrated article dealing fully with all that is modern in the cultivation and preparation of rubber.

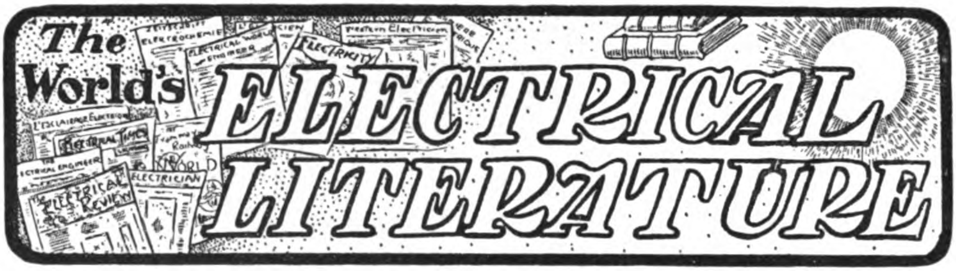
As an artistic production the book is all that one could desire. We can recommend it without reserve.

CENTRAL STATION PRACTICE.

Central Station Electricity Supply. By Albert Gay, M.Inst.E.E., and C. H. Yeaman, A.Inst.E.E. (London: Whittaker & Co. Price 10s. 6d. net.)

The authors are well known as having been engaged for many years in the control of public electricity supply systems; moreover, this is the second edition of a work which has already proved its worth, consequently new readers can take up the book with confidence. The book is written in an easily read style and is essentially practical. It has been the aim of the authors to specialise on the central-station part of public supply undertakings; this they have done, and the only point to take possible exception to is that the title might have been better suited to the contents.

The thirteen chapters cover a wide range of the subject, dealing in turn with history, rules and regulations, steam and electric plant, switchgear, transmission systems, running and management. Where readers may desire to pursue any phase of the contents further, references to other works are interspersed. This is a practical book and will be found particularly suitable to the switchboard attendant, charge-engineer and other aspirants to the post of Borough Electrical Engineer. The student will find in it a concise and simple description of modern central-station practice, and not a few chief engineers of public supply will find much in this volume of value to them.



The World's ELECTRICAL LITERATURE

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Catenary Line Work for Electric Railways.	*Elec. World*, 30/3/07.
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Experiences with Electric Cooking.	*Elec. World*, *March*/07.
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Single-Phase Motors.	*Elec. Eng.*, 1/2/07
Measurement of the Hysteretic Loss at Slow Cycles. G. Knapp.	*Elec. Eng.*, 15/2/07
Armature Reaction in Polyphase Alternators. L. Herdt.	*Can. Elec. News*, *Feb.*/07
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Continuous-current Armature Winding Diagrams. H. M. Hobart.	*Elec. Rev.*, 30/3/07.
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Calculation of the Leakage Reactance of Induction Motors. I. E. Hanssen.	*Elec. World*, 30/3/07.

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The Electrical Plant at the Cocke Creek Works of the Sulphide Corporation, New South Wales.	*Elec. Eng.*, 15/2/07.
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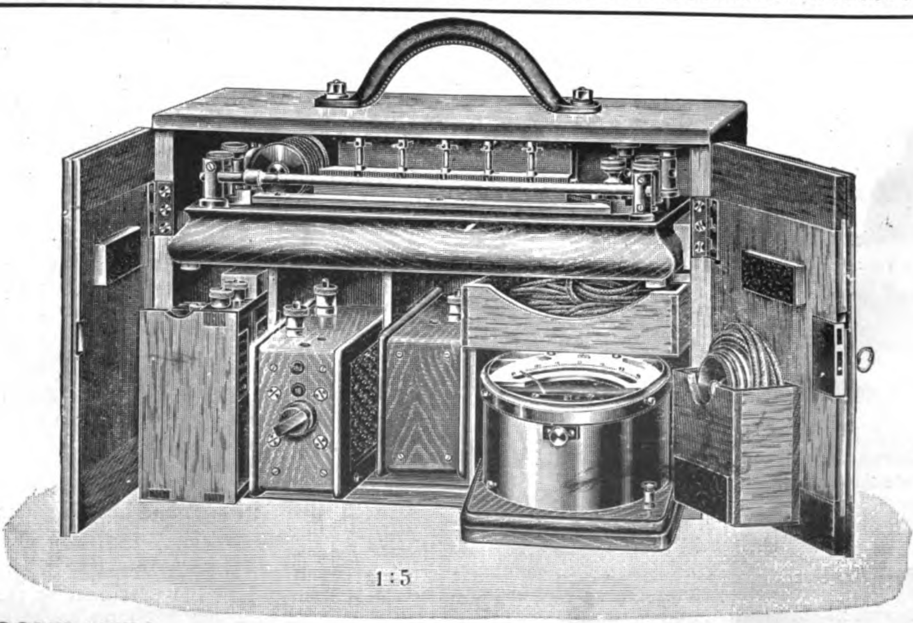

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Trade Notices.

Aerial Ropeways.—MESSRS. JOHNSON & PHILLIPS, LTD., have opened a department for the manufacture of aerial ropeways. The special merits claimed for their system are its adaptability to curves ; loading and unloading facilities; its suitability for inclines up to 1 in 2; the saving effected in the cost of transportation of materials from one place to another.

Westinghouse Work. — THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, LTD., Manchester, are very busy, particularly in the manufacture of turbines and gas engines. In turbines alone there are over 75,000kw. on order, mostly for erection in this country (London, Huddersfield, Rhymney, &c.), but quite a considerable proportion are to go to Japan, Russia, France, and Melbourne. Of turbo-generators, machines to the extent of 40,000kw. total capacity are passing through the shops. One turbo-generator of 400kw. capacity is for H.M. the Czar of Russia, and will be installed to light the palace of Tsarskoe Selo, near St. Petersburg.

The new type of gas engine, which has been on the market some five months, is evidently meeting with success, and orders aggregating 6000b.h.p. have been placed for delivery in Buenos Ayres, Gibraltar, Heysham (Docks), Runcorn, &c.

New Branch Office.—MESSRS. SIEMENS BROTHERS' DYNAMO WORKS, LTD., have opened a London branch at 1, Abchurch Yard, Cannon Street, E.C., under the management of Mr. A. W. Woodyatt. The district controlled by this branch will cover the counties of Bedfordshire, Berkshire, Buckinghamshire, Cambridgeshire, Essex, Hampshire, Hertfordshire, Huntingdonshire, Kent, Middlesex, Norfolk, Oxfordshire, Suffolk, Surrey, Sussex, the Isle of Wight, and the Channel Islands.

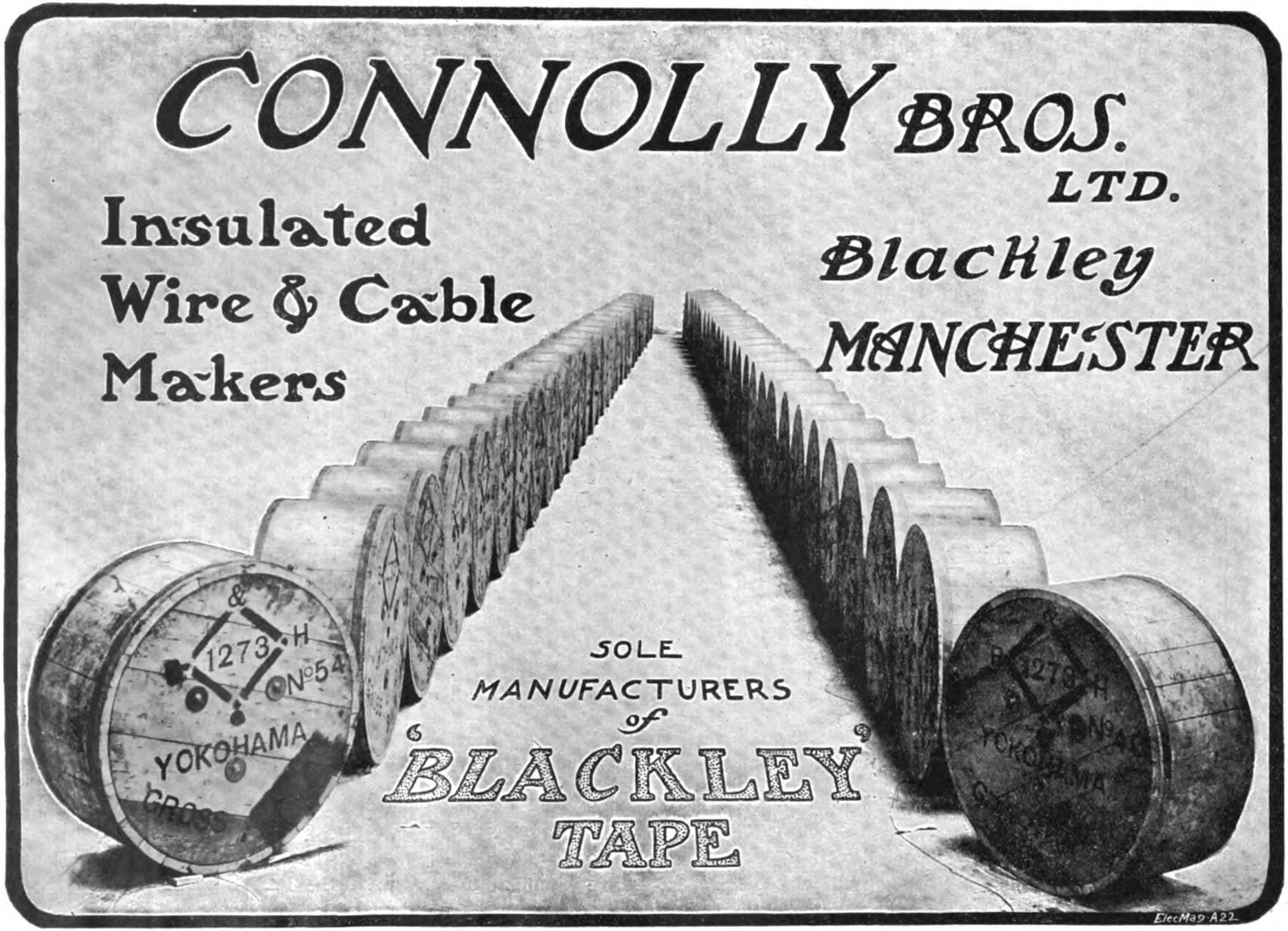
Royce, Ltd., and Rolls-Royce, Ltd.—MESSRS. ROYCE, LTD., advise that they are caused some inconvenience by clients confusing the above titles. The latter firm has taken over the automobile business inaugurated and previously carried on by the former at Cooke Street, Hulme, Manchester, and is continuing the manufacture of the well-known "Rolls-Royce" motor chassis. The offices and works of Messrs. Royce, Ltd., have been considerably enlarged to meet the rearrangement. They are situated at Trafford Park, Manchester (now their only Manchester address), and manufacture the "Royce" dynamo-generators, electromotors, motor-starting and controlling switches, switchboards, arc lamps and accessories, and the well-known "Royce" electrically-driven cranes, hoists, capstans, winches, and transporters. The two firms are totally distinct and separate companies.

British Destructor for America.—The City Council of Seattle, Washington, on the Pacific Coast of America, recently passed an ordinance empowering the City Engineer to negotiate for the erection of a large destructor plant of the Meldrum Simplex type. The order for this plant has been placed with MESSRS. MELDRUM BROTHERS, LTD., Timperley, near Manchester. It is interesting to note that the City Engineer, Mr. R. H. Thomson, M.Am.Soc.C.E., visited Europe in the spring of 1905 and inspected the most up-to-date destructor installations in this country and on the Continent. After being keenly contested by special representatives of both American and British firms in this line of business, the plan advocated by the City Engineer to install a Meldrum plant was eventually agreed upon. It was pointed out that this type of destructor was far in advance of any American practice, and that only recently the City of Paris contracted for the erection of similar destructor plants at three large stations, the total capacity of these furnaces approximating 700 tons per day of 24 hours, this being the largest contract for destructors ever placed. The first successful destructor plant of British make erected on the North American continent was that installed some two years ago for the Corporation of Westmount, Montreal, and the tests there carried out, of which an account appeared in a recent number of THE ELECTRICAL MAGAZINE, proved the Meldrum Simplex destructor to be equally well adapted to deal with American refuse as with English or Colonial refuse.

Condensing Plants.—THE MIRRLEES WATSON COMPANY, LTD., Glasgow, have received orders for condensing plant for the following works : Surface condensing plants : Red Lion Cement Works, Northfleet, one set duty 12,250lb. steam per hour ; West Lothian Sheet-Steel Rolling Mills, Bathgate, one set duty 6500lb. steam per hour ; for Toulouse, three sets each duty 19,825lb. steam per hour. Low level counter-current jet condensing plant : Croxley Mills, Watford, two sets each duty 1500lb. steam per hour.

Nairobi, East Africa.—Messrs. Burstall & Monkhouse, consulting engineers, Old Queen Street, Westminster, have placed an order with MESSRS. JOHNSON & PHILLIPS, LTD., for the supply of high-tension switchboard, sub-station switchgear and transformers on behalf of the Nairobi Electric Power and Lighting Company, Ltd.

The Institution of Electrical Engineers.—As announced by the president at the ordinary general meeting last month, the council have elected Professor J. J. Thomson, D.Sc., Cavendish Professor of Experimental Physics at Cambridge, and Professor of Physics at the Royal Institution, an honorary member of the Institution of Electrical Engineers.



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New Catalogues.

Wire Conduits.—Simplex Conduits, Ltd.—Under the title of "The Real Truth about Enamel," this well-known firm has issued a booklet giving valuable and interesting results of tests made on conduits with the object of ascertaining the worth of the enamel used. Some details of these tests are given in another part of this number.

Power Applications.—The Electric Construction Company, Ltd.—Two small illustrated books, the one dealing with E.C.C. plant as installed for colliery service, the other describing general applications of E.C.C. motors. The latter is particularly interesting in its variety of illustrations and information, and all who are contemplating the adoption of motors for driving works or fixtures should obtain copy of this circular.

Insulating Varnishes.—Pinchin, Johnson & Co., Ltd.—For the advertising of varnishes expressly done for colliery work, this firm has issued three parts of a little publication entitled the *Insulator*. Each of these books contains articles which are bound to be of great service to many of those engaged in the manufacture and maintenance of electrical plant and apparatus.

Dynamo Machines, Starters, etc.—T. W. Broadbent.—This catalogue describes and gives dimensions and rating of a c. and d.c. motors. Single-phase motors are listed as a new line of entirely new design. Full details, such as rating, dimensions, prices, are given of these machines, also similar prices and particulars of a special line of motor switches, regulators, and switchgear.

Cables and Wires.—Johnson & Phillips, Ltd.—A new cable list devoted to Association cables and non-Association, and Paterson's fire-proof types. This last is so well known that details of its contents are here unnecessary. Messrs. Johnson & Phillips advise that they will be pleased to send a copy to anyone interested.

Jib-Cranes and Capstans.—Royce, Ltd.—An illustrated leaflet giving sizes and details of electric jib-cranes and electric capstans as supplied by this firm.

Transformers.—Messrs Johnson & Phillips, Ltd.—An attractive little illustrated circular describing this firm's standard types of air- or oil-cooled transformers as used for single-phase or three-phase circuits.

Voltage Regulators.—The British Thomson-Houston Company, Ltd.—Pamphlet No. 200 gives a complete description and technical information regarding the work of B.T.H. voltage regulators as intended for a.c. and d.c. generators.

Switches.—Johnson & Phillips, Ltd.—Price-list S, is devoted to main switches, and gives prices and descriptions of enclosed double-pole switches, also those of gas- and water-tight construction and of oil-break types.

Siemens Dynamo Works, Ltd.—We have received a batch of new circulars from this firm covering a wide range of specialities.

Circular Y.M. 108a contains a description of an electric control for ship steering gear.

Circular Y.M. 115 is the reprint of an illustrated article describing an electrically-operated slipway as built at Dublin.

Circular Y.M. 116 describes a belt-driven automatic motor starter as suitable for pumps and similar purposes.

Y.M. 118 also describes an automatic starter fitted with auxiliary motor; this type in addition to the foregoing has a spark extinguisher arrangement.

Y.M. 119 describes a line of tripping switches as intended for use in connection with hydraulic accumulators, &c.

Circular Y.M. 120 describes typical applications of Siemens machines for power service in paper mills.

Union Dynamos and Motors.—Union Electric Company, Ltd.—Price-list No. 1005 gives capacities, dimensions, and prices of a line of small motors ranging from ¼ to 2¼b.h.p.

Switchgear.—Crompton & Co., Ltd.—A complete catalogue, giving particulars and prices of switchboards and all classes of switchgear as made by this firm. It should be noted that the prices given in this list include packing and delivery, which, we are advised, has not been the case in previous lists of this kind issued by Messrs. Crompton.

A.C. Instruments.—Crompton & Co., Ltd.—Price-list No. U14 is a price-list of various types ot switchboard instruments as used for alternating-current circuits.

Testing-Room Appliances.—Crompton & Co., Ltd.—Catalogue U15; prices and particulars of several testing-room specialities, such as galvanometers, resistance apparatus, standards, and other testing-room appliances.

Electric Heating Apparatus. — A.E.G. Foreign Department.—Price-list No. 10 (VII.) illustrates and describes with prices a very large assortment of electric cooking and domestic heating appliances, too numerous and various to mention in detail. This catalogue should be in the hands ot every housewife.

Ammeters and Voltmeters.—Johnson & Phillips, Ltd., send us a copy of their price list M.I., describing and giving dimensions and prices of dead-beat, moving-iron instruments. These are suitable for d.c. and a.c. circuits, and may be supplied either of the round or sector pattern in iron cases for switchboard use, or in polished walnut cases for portable purposes. The prices are very reasonable, and all interested in the purchase of instruments for everyday use should obtain this circular.

A Useful Present.—The Phœnix Dynamo and Motor Company, Ltd., have sent us a useful embossed copper pen-tray, a number of which they are distributing amongst their clients. It is of handsome design and is sure to find a permanent place on the desk of fortunate recipients.

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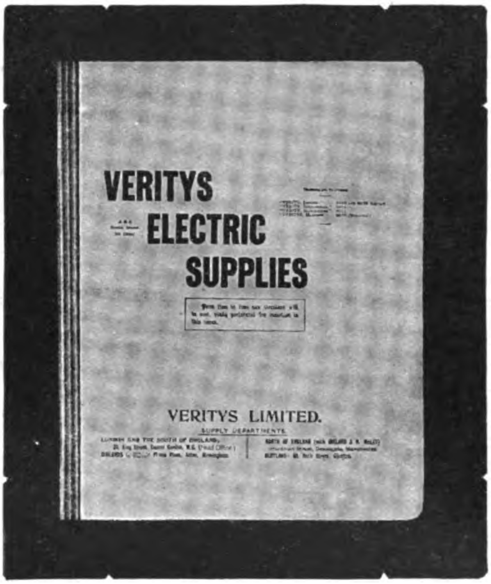

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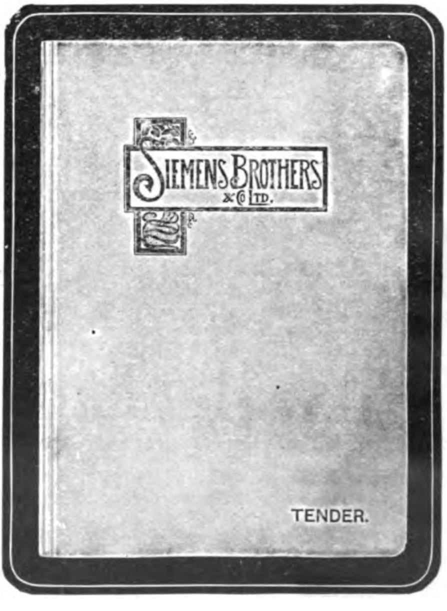

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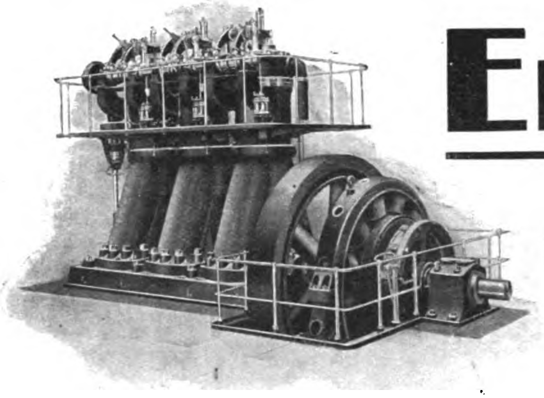

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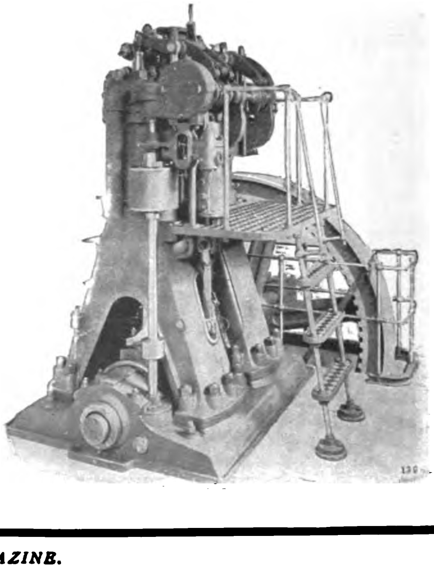

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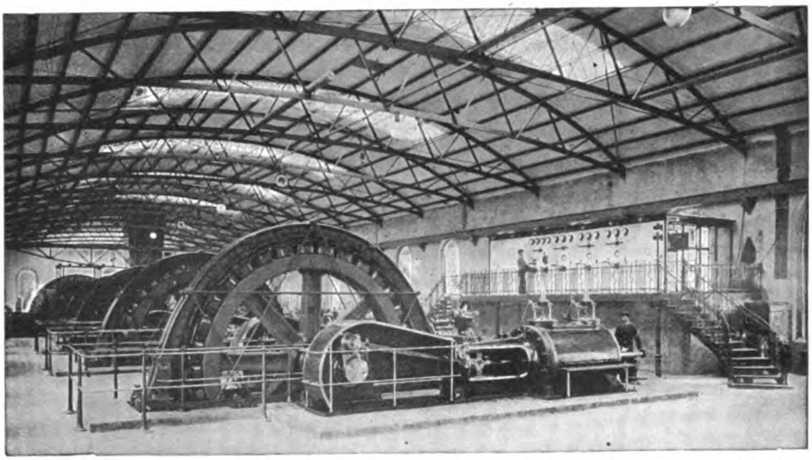

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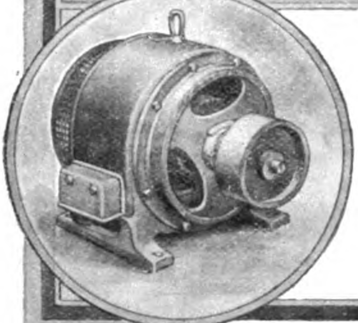

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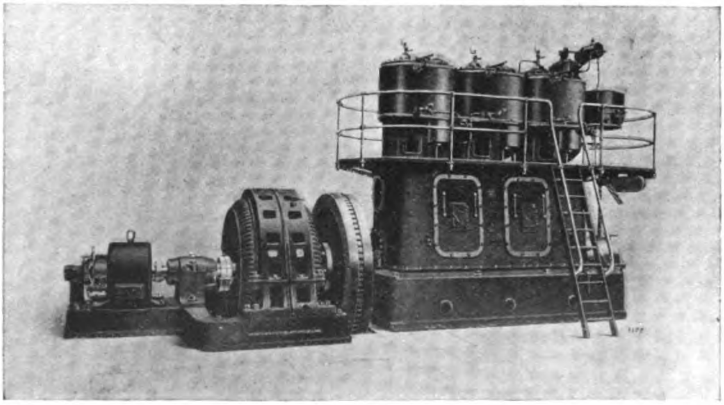

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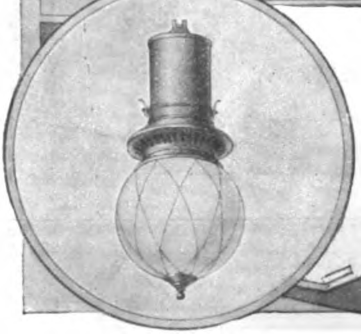

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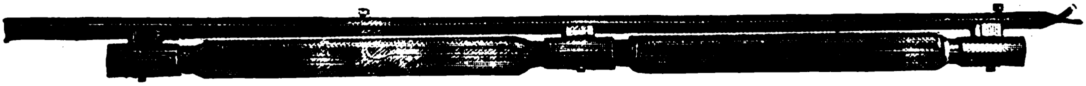

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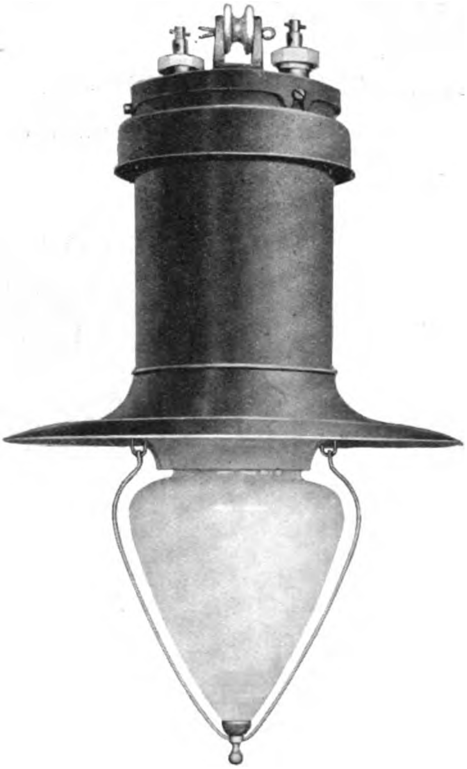

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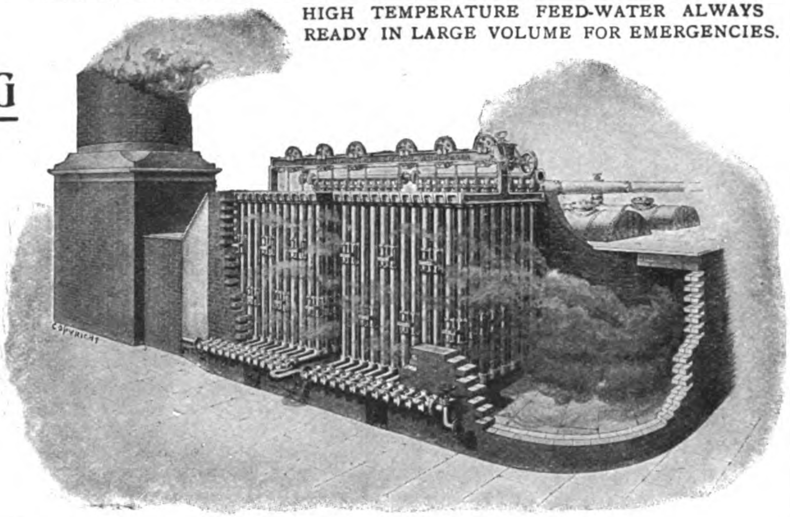

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The

Electrical Magazine.

FOUNDED AND EDITED BY

THEO. FEILDEN.

VOL. VII. No. 5. (41st Issue.) LONDON. MAY 28th, 1907.

The World's Electric Progress.

ELECTRIC POWER IN TEXTILE FACTORIES.

At the present time we are engaged in the production of a special number of THE ELECTRICAL MAGAZINE, in which the latest practice in the application of electric power for driving textile machinery will be dealt with in a more thorough and specialized manner than has ever been attempted in a periodical journal. The reception accorded our Colliery Number was distinctly gratifying, and a second edition was called for within a week of its appearance. Such a result is encouraging and gives zest to our endeavour to produce from time to time specialized numbers of this journal, each devoted to a full treatment of the use of electricity in one or other of the principal British industries.

The second of the series, now in course of preparation, is to be devoted to textile manufacture. It may be said in general that the advance of electrical power in the driving of cotton factories has been due very largely to the prosperity which that industry has enjoyed of recent years. New mills have sprung up in the Lancashire cotton districts, additions to existing factories could not be effected too quickly, and the electric motor —light and convenient, delivered from stock—came into recognition. And it has come to stay; running results have proved its great economies and advantages. Not only in the modern-built factories does it hold undisputed sway, but it has already, after two or three years' service, ousted the mill-engine from the foundation where it has rested for generations. This is not the place wherein to enter fully into the details making for this sweeping change—that will be the theme of our Textile Number.

We are getting into touch with all those most concerned in the making of fabrics, in the supply of machines for that purpose, and in the electrical driving of those machines In this Kingdom and in the Colonies the leaders of the several industries which enter most closely into the equipment and operation of textile factories are interesting themselves heartily in our venture and extending us their invaluable support. Readers connected with these branches of engineering who have practical suggestions or novel ideas to reveal as the result of experience should note that we would welcome any communication from them they care to send us.

Exclusive articles by experts on the electric driving of textile factories will form an exceptionally valuable feature of our Textile Number, which will be illustrated by numerous interesting photographs specially taken for THE ELECTRICAL MAGAZINE. As an indication of the thorough manner in which the subject will be treated, we might mention that separate consideration will be given to such phases as: cotton-mill driving as it exists; the machines and their arrangement throughout the mill; the horse-power required for each class of machine; the mechanical arrangement of the drives in each case; the size of the electrical units and their disposition in the mill; typical examples of electrified factories; statistics of results and economies obtained; the future of electricity in the textile industries, &c. The number will be rendered as complete as possible; it will form an invaluable compilation of the most interesting and useful facts, and will be of the greatest technical and commercial importance to textile manufacturers, textile machine makers, and manufacturers of electrical plant.

The Textile Number of The Electrical Magazine will have the widest circulation amongst millowners and workers in the textile industries throughout the world, whether engaged in the handling of cotton, wool, flax, jute, or silk. It is intended to produce a work of standard reference for those seeking after the most modern practice in the power requirements of textile mills, ranging from those manufacturing heavy goods, such as carpets, blankets, and calicoes, to those turning out the lighter cambrics, laces, and silks.

The Frosted Lamp.

The use of frosted bulbs for diffusing the light of the incandescent filament has been general almost since electric lighting came into being, and the principle is ever increasingly finding favour amongst those by whom a perfectly comfortable light is desired. At the same time it has become generally known that the lasting qualities of the frosted lamp are much inferior to those having plain bulbs. The extent of this disparity between the two types, and its cause, forms the subject of two articles appearing in our Lighting and Heating Section this month. In both cases practically the same results are arrived at.

It is not that the actual life—up to the filament breakdown point—is shorter with the frosted than with the plain lamp, but that the effective candle-power of the former falls off much more rapidly than that of the latter. There is no reason to suppose that so far as the filament itself is concerned there is any difference in the respective rates of aging. The explanation of the comparatively rapid deterioration of the frosted lamp is extremely simple, and no one can doubt that it is, as both authors have deduced, entirely due to the combined absorption and reflection of the frosted bulb and its coatings, internal and external: the internal coating being the "blackening" fine carbon deposit; the external coating being dust. With a new frosted lamp the absorption of the glass is greater than it is in a plain lamp, and the reflection of a larger proportion of light back and forth across the interior of the lamp (at each reflection the light losing by the glass absorption) is the cause of the rapid reduction in candle-power since the blackening film increases the absorption of the reflecting and ever less transparent glass.

As to a cure for this, it would appear an insurmountable fault whilst carbon filaments are used; but with the new metallic filament lamps the deleterious effect of an internal deposit on the bulb of a frosted lamp should be considered as of great importance in their development. It is, however, claimed that the new lamps do not blacken, and it would appear quite reasonable to expect that this should be so, considering the excessive temperatures, far above those of normal operation, to which these filaments can be raised during the stages of lamp-making.

The Preparation of Tungsten Filaments.

As of interest in the subject of modern lamp developments, a subject which is probably receiving more attention than any other from electrical searchers and inventors at the present time, and as bearing upon our preceding comment on metallic filament lamps, a patent recently taken out by a German syndicate should be mentioned. The protection is sought for a process of heating tungsten almost to its melting point as a preliminary process of lamp making. The heating is effected on the formed filaments and by electricity. This is done by connecting up the filament to be treated in the same manner as an ordinary incandescent lamp filament, either in vacuo or in an indifferent gas, and heating the same to a very high degree by means of the electric current; or the filament may be heated in an electric arc generated between tungsten electrodes. The tungsten incandescent body to be employed subsequently in a lamp should, in the preliminary process, be heated to a degree corresponding to at least 1 watt per candle-power. This intense heating will in a short time render the filament sufficiently constant for practical purposes for a consumption of from 1 to 1.5 watts per candle-power.

The advantageous effect which has been found to follow this heating is stated to be probably due to the fact that the filament gives off all of its impurities in the high temperature and becomes denser. It is stated that if an osmium filament is heated considerably above the usual temperature, it becomes so ductile that it can be easily rolled to a spiral without breaking, but at the same time its electrical resistance falls to a most extraordinary extent; on the other hand, the effect of this high degree of heating on tungsten produces no alteration whatever in its physical properties.

❧

Insurance and the Rating of Machines.

THE conditions imposed by those insurance companies who make a speciality of machinery and plant risks have had not a little to do with the perfection of design and workmanship put into electrical machines. The care of electrical apparatus and its maintenance are not the only phases of practice in which they interest themselves: the paper by Mr. Llewellyn Foster included in the Wiremen's Section of this number is very complete in detailing practically every form of breakdown to which dynamo-electric machinery is subject, and contains much valuable information as to the ways and means of preventing such failures. The author deals alike with the care of machines and with their mechanical design: his suggestions and criticisms are based upon the records of insurance, he acknowledging indebtedness to Mr. Michael Longridge, chief engineer of the British Engine, Boiler and Electrical Insurance Co., Ltd., for much of the data given.

It is to be regretted that the author of the paper did not give more attention to the need of a proper and uniform system of rating electrical machines. It is indisputable that a very large percentage of breakdowns are altogether attributable to inconsistencies in this direction. This is well known to all those who have had experience in general power installation work; and it is particularly noticeable that where motors are used for variable-speed work, for intermittent short runs, and as enclosed machines, there the electrical breakdowns are most frequent. The insurance companies are in the strongest position for compelling uniformity amongst makers and users as to what shall be the horse-power, speed, load-time, and heating limits for a machine intended for any particular service. Let them give this their thorough attention, and great benefits will accrue to all concerned—to themselves, to the manufacturer, and to the user.

As confirming this, readers should note with interest the rules which the National Board of Fire Underwriters, U.S.A., have recently suggested regarding the rating of variable-speed motors. An abstract of these is as follows:

> All variable or varying-speed, alternating-current motors must be marked with the maximum current which they can safely carry for five minutes and thirty minutes respectively, starting cold.
>
> Varying-speed motors are motors in which the speed varies automatically with the load, decreasing when the load increases, and *vice versa*. It does not mean motors in which the speed is varied by the use of different windings or groupings of windings, or motors in which the speed is varied by external means, and in which, after adjusting to a certain speed, the speed remains practically constant.
>
> From these two "time and current" ratings the safe allowable current for any other length of time between five and thirty minutes can be determined by interpolation. The amount of current which a motor can safely carry for any given length of time is limited by the maximum allowable heating of the motor. This maximum temperature may be due to a certain current for a given *continuous* length of time, or may be reached as the result of different currents for various times, including periods of shut-down, during which the motor has a chance to cool somewhat.
>
> Therefore, for any given set of conditions the final temperature is the same as that due to a certain current carried for a given length of time. Hence, for any particular service the problem for purposes of rating the motor is to estimate the time thus represented by the conditions, and from the five-minute and thirty-minute ratings of the motor in question to determine the current corresponding to this time. This current is then to be considered as the rated current, and the leads or branch wires selected as required for this current. The following classification of the more common services will serve as a guide in determining the "time" represented by any given condition:
>
> Five-minute class:
> *a.* Operating valves.
> *b.* Raising or lowering rolls, tool heads, &c.
>
> Ten-minute class:
> *a.* Hoists.
> *b.* Rolls.
> *c.* Ore and coal-handling machines.
>
> Fifteen-minute class.
> *a.* Freight elevators.
> *b.* Shop cranes.
>
> Twenty-minute class:
> *a.* Passenger elevators.
>
> Thirty-minute class:
> *a.* Rolling tables.
> *b.* Pumps.

Good Advice.

THE following little homily on the value of a good social reputation, as a factor making for an individual's general success, appeared recently in our colonial contemporary, *The Canadian Manufacturer*. Its teaching is so indisputably correct and yet so often ignored that we are constrained to reprint it for the benefit of our younger readers. After all it is merely an elaboration of the old adage that "all work and no play makes Jack a dull boy," excepting that it goes farther and points out how the dulness is responsible for actual loss in money-making and in real success.

Young men who are ambitious to amass money often make a great mistake in thinking that it is a waste of time to cultivate their social faculties, that society has nothing to do with money-making; they think that spending time in society is a hindrance, that it will keep them back.

The result is that there are multitudes of well-to-do men in this country who can scarcely say their souls are their own in a drawing-room or elsewhere in society. They are simply dummies. They can talk only about their business. They are dumb upon other subjects. They taboo what is called society. It is a bore to them simply because they have never developed their social qualities. They do not like the drawing-room because they do not feel at home there. It is a stupid place for them. They do not know what to do or to say. They are strong in their little business rut. They are at home there. If you call on them in their offices they are strong, resourceful; but the moment they put on a dress suit and go into a drawing-room they are mere sticks, weaklings, not the giants they were yesterday in their offices, or factories, or stores. They feel restricted, shackled, out of place, just as one feels when trying to be natural before the camera.

They are in a way paralysed, because faculties of an entirely different kind from those used in their business are called upon to act, and they are unused to it; those particular faculties are untrained, not ready to respond to the demand upon them. Men with a tithe of their ability far outshine them in the social circle, put them entirely in the shade, make them feel very uncomfortable indeed, and as if they were "nobodies."

Many college men think it is a waste of time to go into society. They think they must spend the precious hours grinding away at their books. The result is that these men often gain a great deal of learning, but, as they have never cultivated their conversational powers, or their social side, their knowledge is largely unavailable.

If you are cold, self-centred, and uninteresting, if your greatest wealth is not in shape to give to others through your conversation, your social intercourse, what does the world care about your position?

Medical Electricity.

DESPITE the fact that electricity has always been, and is still, to a very large majority synonymous with magic and mystery, and as such has been seized upon by quack doctors and swindlers galore as the panacea to relieve all ills incidentally and the patients' pockets primarily—despite the name and sometimes the current being utilised in this unscrupulous manner, there has been genuine work done in the sphere of medical electricity. It is not all who believe in the efficiency of electric baths—such cases of alleged benefits as come to their direct notice are attributed to "faith-healing" by those who must have the reason of the cure from A to Z before conviction. To such obstinate cases we commend the opening article of the "Medical Electricity" section, which appears in this number. The author, Dr. Arthur Roberts, of Harrogate, is well known as a leading specialist, and he writes fully and critically on his subject of the use of the modern subdivided, or "four-cell," electric bath. The very principle of providing separate liquid poles for each limb appeals to the electrical man as merely the common-sense way of ensuring, as far as is practicable, the current passing through and not around the patient; and moreover, that this method only will permit of any reliable indication of the current strength being obtained. He also will, as will every thinking man, appreciate the immense possibilities of the use of electricity for cataphoresis—the admission of medicines into the human system by way of the pores of the skin; chemical analysis, indisputable evidence, proves that this effect can be depended upon.

The use of electricity as a curative and palliative agent in sickness and disease receives constant attention from the cleverest scientists of civilisation; remarkable discoveries and perfection of detail have already been made and substantiated, but we are led to believe that only the fringe has been touched—sooner or later, but inevitably, will come the discovery whereby electricity shall put an end to the three or four diseases in the curbing of which we are still powerless and to the ravages of which we are so vastly subject.

POWER: and its application to INDUSTRY

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Power, its Generation, Transmission, and Distribution.

*The Use of Wooden Poles for Overhead Power Transmission.**

C. WADE.

The power companies have necessarily been the missionaries of overhead transmission in this country. They soon found that in many cases the cost of underground mains made it unremunerative for them to connect on customers whom they needed and who needed them. The Lancashire Electric Power Company was the first in England to bring the point to an issue. They approached the Board of Trade, and were met by the authorities in a most friendly spirit. Plans were submitted and approved, way-leaves were arranged, and to-day the Company has about 4½ miles of overhead mains safely, economically, and reliably transmitting power at 10,000 volts pressure to a variety of industries. The lead of the Lancashire Power Company was quickly followed by the South Wales, the North Wales, the Clyde Valley, the Cleveland and Durham, and other companies, and there are now some 55 miles of extra high-tension overhead transmission lines at work in Great Britain.

To those who have studied the subject—especially abroad—it seems strange that this country can only boast, in 1907, of having 55 miles of overhead mains at work. In the districts round Grenoble, Lyons, and at St. Etienne, to give only one example, there are some 700 miles of overhead power mains at work, carrying energy at pressures varying from 200 to 26,500 volts. These mains are for the most part carried on ordinary telegraph poles along the sides of the main roads, and are looked on by the inhabitants as part of their daily surroundings and as necessary to their prosperity as the high roads and railways of the districts.

One overhead line near St. Etienne, 11 miles in length, carrying energy at 5500 volts pressure, was erected for £160 per mile, and this sum included way-leaves, special precautions when crossing roads and railways, and the purchase of trees that were in the way of the line. It is interesting to note that some 4000 silk looms are connected to these mains, divided amongst hundreds of peasant proprietors who own from two to ten looms each. This is a very striking example of the benefits of cheap electrical power rendered possible by the employment of overhead distribution.

The first extra high-tension overhead line in this country was put up—more or less—by rule of thumb. There were no reliable data from which to settle the requisite strength and size of poles employed. The subject was one of the greatest importance, as it was essential, on the one hand, that the capital cost of the construction and erection should be kept as low as possible; and on the other hand, that overhead transmission should not be discredited by failure, accident, or disaster. The author therefore, in August and November, 1906, acting on the suggestion of Mr. A. P. Trotter, of the Board of Trade, carried out an exhaustive series of tests on wooden poles of varying form, lengths and diameter. During these tests the author had the advantage of the advice and help of Professor Goodman, of Leeds.

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* Abstract of Paper read before the Institution of Electrical Engineers, May 2, 1907.

The first set of tests was carried out in August, 1906, and both single and double poles were experimented upon. The results, however, were not considered satisfactory as the arrangements for testing were found to be far from perfect. The method adopted of loading and holding the poles caused a large amount of friction and prevented accurate results being obtained.

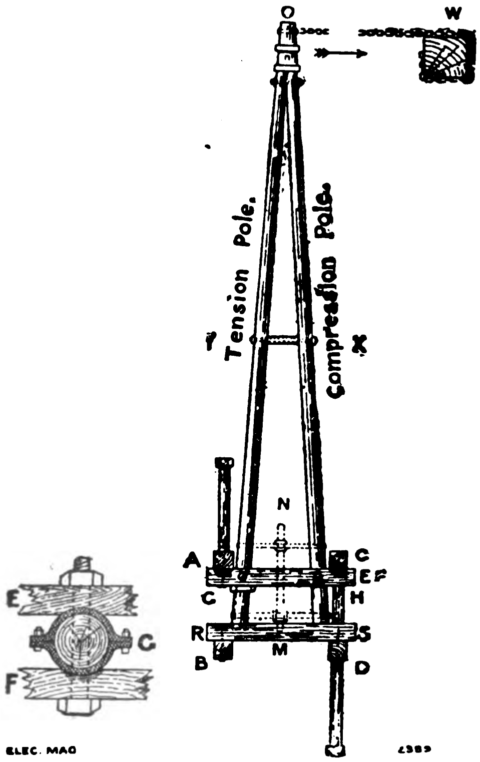

Fig. 1.

These tests clearly proved: First, the very marked superiority of an "A" over a single pole, the "A" pole being shown to be at least three times as strong as a single pole, while later and more accurate tests have shown that the "A" is at least four and a half times as strong as a single pole. Second, the great flexibility and recuperative power of wooden poles. Some single poles that were tested projected free for 35ft. from their housing and deflected 13ft., 14ft., and 15ft. before breaking; and those that were released before the breaking-point was reached showed a very small permanent set. It was soon seen that "A" poles were preferable to single poles both as regards economy and strength. To obtain the required strength *in single poles*, they would have to be of such a diameter as to be prohibitive in cost, and in some cases unobtainable. Most attention was therefore bestowed on testing the strength of "A" poles and on finding out the best method of constructing them.

It being desired to hold the butt of the pole firmly to a height of 5ft. whilst the rest of it was allowed to swing free, two heavy timbers were driven into the ground, one for holding the foot of the pole, and the other for taking the stress 5ft. up. The top end of the pole was supported on a specially constructed trolley, which ran on a platform under this end of the pole. It was first attempted to load the pole by weights placed on a wooden platform suspended from the end of a wire rope attached to the pole, and carried by a series of pulleys to the top of a substantial frame about 12ft. high. The platform when heavily loaded sank into a pit dug below the frame.

This method was quickly abandoned on account of the friction of the pulleys and the time occupied in loading by this crude means. In subsequent tests the load was obtained by a gang of men with pulley-blocks, a dynamometer being inserted in the loading chains.

A similar method of holding was adopted in testing "A" poles on the flat—*i.e.*, along the line of the wires—and was satisfactory. This acted admirably for single poles, but when "A" poles were tested across the line of the wires in precisely the same manner it was found that, owing to their taper construction, there was so much end slip in the housing that accurate results were impossible. When it was found that the strength of "A" poles was the really important point to determine, the author, acting on Professor Goodman's suggestions, redesigned and reconstructed the testing apparatus and the methods of housing the poles, and carried out a new series of tests in December

In this series of tests—confined almost entirely to "A" poles—a different method of holding was adopted to prevent the poles from slipping in their housing, as shown in Fig. 1. All the poles were about 7½in. to 8in. diameter at 5ft. from the butt. The double pole being placed in position, as shown, two heavy blocks E F were bolted to it, one below and one above the pair of poles about 2ft. 6in. from the butt, and, in addition, a heavy iron ring G was bolted to the tension leg of the pole, below the blocks, to prevent them slipping down when under load. The foot of the pole was embedded against a massive timber R S, supported on the poles B D. A block H was inserted, as shown, to give additional stability.

By this means when the load was applied in the direction of the pile W, the leg that was under *tension* was unable to move away from the balk A and its supports on account of the oak cross timbers, whilst the leg that was in *compression* was also unable to move as its foot was pressing against the timber R S. The pole was therefore very rigidly held in place, in fact, far more so than would occur in actual practice.

Professor Goodman suggested and provided a telescope, which was attached to the butt of the pole at M N (Fig. 1), and by this means it was possible to sight a plumb-bob, suspended at O, so that accurate readings could be obtained and any slip of the pole in its housing could be detected and allowed for. The use of a telescope in tests of this kind is a very necessary refinement that is too often overlooked, and one was used by the author in all tests made. The housing requires to be of great strength. The author believes that the results of these tests are accurate, as very great care was taken to make them so. In all probability if a load equal to the test-load were applied to a pole carrying wires the whole structure would be pulled out of the ground.

The load was applied in the same manner as in the first series of tests—by pulley blocks—and everything possible was done to eliminate friction. The weight of the pole was taken at the top end by a chain hung from a large pulley running on an overhead cross-pole supported on tripods at each end. This pulley was guided by a line on each side, and the cross-pole was fixed as nearly as possible level and in the line of the pole's deflection.

In these tests it was found that whereas a single pole would often deflect to a very large extent before breaking, an "A" pole, so long as it held together at the top, would only deflect a few inches. The "A" pole, however, would sustain in a direction across its two members—*i.e.*, at right angles to the line—a load four or five times as great as that of a single pole of the same diameter as one of the two members of the "A" pole. Also experiments show that an "A" pole (as would be expected) is at least twice as strong as a single one of equal section, in the direction of the line, and would only deflect half as much.

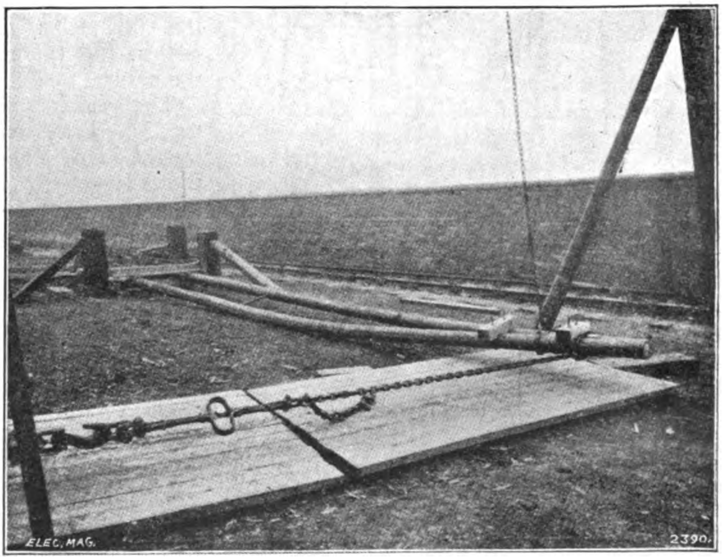

Fig. 2.

Fig. 2 shows how the "A" poles failed in nearly every instance through the buckling downwards of the member in compression. This was due to the initial sag of this member, caused by its own weight, which it was impossible to allow for. To have eliminated this sag it would have been necessary to support the poles in the centre, which would have caused friction, and this it was

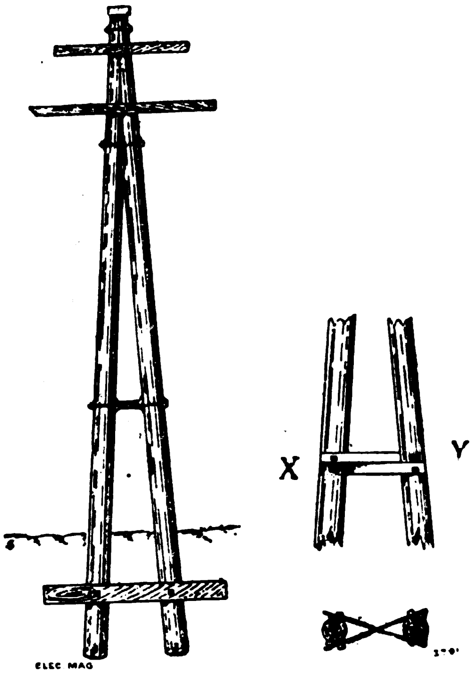

FIG. 3.

particularly desired to avoid on account of such friction affecting the accuracy of the results. This sag undoubtedly made the poles fail sooner than they would have done had they been in a vertical position, and the results, therefore, are less favourable than they would be in actual practice. But it should be noted that at this point of failure the poles were not actually broken in any way, and if it had not been for the sag out of the line of pull they would undoubtedly have sustained far greater loads. The buckled pole in all cases straightened itself immediately the load was released. In every case the load was applied approximately 2ft. from the top of the pole, this being about the point where the stress would occur in actual work.

In 1885 Mr. (now Sir William) Preece, Chief Engineer to the Post Office, carried out a series of tests as to the strength of single poles. Many different kinds of poles were tested that had been seasoned for different lengths of time, and tests were made on creosoted and plain poles, of different lengths and diameters. These tests, however, did not deal with the flexibility of the poles, nor with their strength, as compared with composite poles, but they are still the only data that we have on the strength of ordinary poles.

From the tests carried out by the author it appears that many of the poles in use in this country are misproportioned, and this applies particularly to "A" poles. Some are ridiculously too large while others are dangerously too small. The few that are correct in length and size have been selected more by luck than judgment. The tests showed that the usual breaking-point of a single pole when tested to destruction is 5ft. above ground level, or about 10ft. from the butt. The diameter of a pole at this point is, therefore, the most important dimension to consider in choosing one suitable for certain loads. The top diameter of a pole is also of some little importance, but this is a dimension which Nature settles, and there is no object in altering the natural taper.

The weakest point of an "A" pole is the top, where the stress due to windage and weight takes place. The two members of the pole—owing to their shape—have a tendency to slide and slip on each other when subjected to a load at the top. The important thing about an "A" pole is its construction and the method adopted to hold its two members at the top. The author's method of securing them is shown in Fig. 3. The two members are scarfed to such an extent as to reduce them to about two-thirds of their original diameter. The length of the scarf depends, of course, on the angle at which the members are set. They are held together by two $\frac{3}{4}$in. bolts, one about 12in. and the other about 48in. from the top of the poles. At the foot the two members are tied together by a wooden block about 6ft. in length, and 4in. × 8in. in section, which is let into and bolted to each about 2ft. from the butt. It will be noticed that the arrangement is similar to that adopted in the tests, which were designed to follow, as closely as possible, the conditions occurring in actual practice.

A centre tie-bolt and tubular distance piece is also used between the two members about 10ft. above the ground level. Instead of this tie-bolt, flat iron plates, fixed diagonally across the poles and bolted to the pole at each end, can also be used with advantage, by which means, undoubtedly, the pole is materially strengthened, and is prevented from twisting. Angles or channels bolted to each side of the pole, across the two

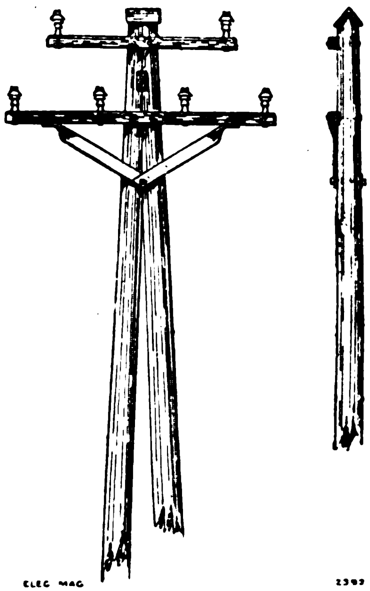

Fig. 4.

members, serve the same purpose. It is also desirable to insert an oak block in the scarf. This block should be 6in. deep, and should be let into each member to a depth of about 1 in., depending on the size of the pole used (Fig. 4). The tests showed that if the blocks are less in depth or if they are nearly square they tend to twist and bed their corners into the poles and thus force the members apart. One deep block in the scarf appears to be better than several of less depth, inasmuch as the insertion of several blocks weakens the timber, and if they are fixed high up they will—when under stress—squeeze the top part of the member on which they bear clean out of the end of the pole. The oak arms let into the poles to carry the insulators materially strengthen the structure and prevent shearing. For the construction of "A" poles the author recommends this method, which is the one usually adopted, but other methods are sometimes employed.

The lower insulator arms are sometimes tied to the centre of the pole by flat ties or iron plates, which helps to prevent the twisting of the arms and the parting of the two members. The tying together of the ends of the lower and upper arms also helps to strengthen the structure. It is, of course, most important that as little cutting away as possible be done to the poles, especially at the top, as this weakens the timber.

Whether insulator arms should be composed of oak or angle or channel iron seems a very open question, into which the question of insulation and earthing enters very largely. The life and strength of a wooden arm seem to be equal to those of an iron one, if not more, and wooden arms will no doubt outlast the pole, and are slightly cheaper than iron. The author has carried out experiments with different forms of castings designed to hold the two members together at the top, both when scarfed and unscarfed. The poles were placed together side by side and held together at the top by the castings.

First (Fig. 5) experiments were made with a casting which enveloped the two members of the "A" pole, after scarfing, between the two usual oak arms. This casting was made in two separate halves, held together by three strong bolts passsing through them and between the two members of the "A" pole. The casting was so designed that when drawn up tight on the pole the two halves of it did not quite meet, and at each end of it flanges were formed for the attachment of the two oak arms, these arms being let into the pole to assist in preventing twisting of the members of the pole. The arrangement seemed to hold very well, and only failed in the end through the splitting of the casting as shown, probably owing to a fault in it, or through having been tightened up too much in fitting it to the poles, which thus sustained a comparatively small load, but gave a comparatively small deflection on

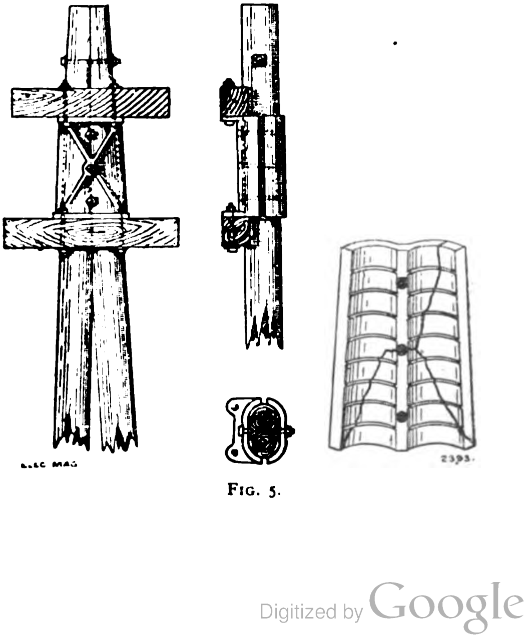

Fig. 5.

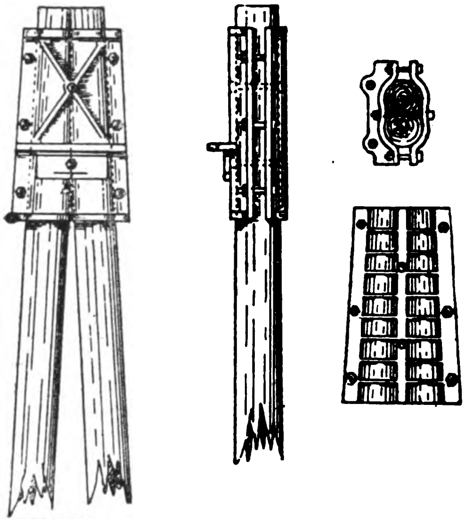

FIG. 6.

account of the rigid manner of tying at the top.

The second casting was formed to envelope the two members of an "A" pole when tied together at the usual angle (Fig. 6) without being scarfed or bored in any way at the top, and it was made in two pieces as in the previous case, but was bolted together at the edges as well as in the centre. This failed in the first instance through the slipping of one member of the pole in the casting, whilst the other held fast, the failure being due to the inequality in size of the two members, in consequence of which the casting did not obtain an equal grip on both members. This was afterwards remedied by the careful selection of two members of equal size, when the result was more satisfactory, and the pole, with one exception, sustained a higher load than any other and gave a comparatively small deflection, failing in the end through the buckling of the compression member. The slip of the two members on each other at the top was practically nil. In the author's opinion this is the best means of tying the two members together at the top, and would seem to justify the extra cost involved by the more satisfactory results obtained.

A means of holding the two poles together was also tried in which the two members were scarfed together in the usual way and the arms were secured to the poles by wrought-iron bands, the ends of which passed through the arms. A centre bolt was also passed through the backing plate to the other side of the clamp as an additional means of tightening up. An oak wedge was driven up between the two poles to give rigidity, and was held in place by these bolts, and as an additional precaution both members were bolted together by a through tie bolt passing through them at the top and also through an oak block inserted in the scarf at this point. The result obtained was distinctly good, the load being high before failure, although the deflection was fairly large.

This method of holding was considerably improved by placing the oak arms below the plates and letting them into the poles, which gave them an additional means of preventing twisting. The result obtained showed a great improvement, the load being higher and the deflection distinctly less.

A method was also tried in which a solid casting was placed over the two members after being scarfed, and having been closely fitted, was secured by a bolt passing through the two poles at its base. This gave good results, but the casting shifted considerably out of the perpendicular under load. The casting originally was formed with a flange to carry the oak arm some way up. Though the load sustained was good, it was not enough, in the author's opinion, to justify the necessary expenditure.

This shifting was avoided to a great extent by the insertion of an oak block in the scarf, and an oak arm let into the pole lower down also assisted in preventing twisting. When tried again the pole gave better results, but not so good as was expected. It failed in the end through the fracture of the tension member.

It would, no doubt, be better to place the flange lower down, at the bottom of the casting, and to let into the pole the arm carried by it. This is a cheap arrangement, and, in addition, it has the advantage of excluding all wet from the top of the pole, and also of forming a cap for it, which can be drilled to receive the insulator pin of one line when it is desired to place the line at the top of the pole.

A heavy "A" pole, each leg being about 11in. diameter at 5ft. from the butt, which had been previously tested last August, was tested again in February; failure in the end was caused by the twisting of the oak blocks in the scarf. These, which had been made nearly square, were replaced by longer ones.

Fig. 7 shows the effect of the enormous stress on these blocks. The pole was then tested again and the load it carried was the highest obtained—about 4 tons, the deflection being only about 14in.—not very great considering the weight on it. The final failure was caused, partly by the twisting and splitting up of the blocks in the scarf, but principally by the twisting of the oak cross-pieces, which took the load at the foot. These gave way under the enormus pressure they had to bear and further results were unobtainable although the two members were perfectly sound at the finish, and not in any way cracked or bent to any visible extent.

Tests were also made with "A" poles spread to different widths at the bottom. The spread which gives strength combined with cheapness of erection was found to be about 4ft. on a 32ft. pole, or a taper of about 1 in 8, the measurement being made between the centres of the bolts holding the brace, which tied the members together near their butts. If a smaller spread than 4ft. is adopted the poles are not so strong, while a greater spread, though giving some extra strength, increases the cost of excavation and way-leaves.

A favourite form of constructing a double pole is the "H" formation, wherein the two members are erected parallel to each other, and are held together by the arms at the top, being strengthened lower down by cross-bracing or by tie bolts. Their strength depends, of course, entirely on the method and amount of bracing, and if this is extensively done, they will, no doubt, be as strong, if not stronger, than "A" poles of equal size. They have the advantage of presenting a greater surface than an "A" pole to which to attach wires, and are especially useful for terminals of lines for this reason. When used as terminal poles they are stayed with two or four steel rods or wire ropes at the back, to take the stress of the line.

This "H" formation is also extensively used by the leading users of telegraph lines and telephones for main routes, where the poles have to carry a large number of wires, and where a single or "A" pole would not give the requisite surface.

One advantage of wooden poles that the tests have conclusively proved is their great flexibility and recuperative power after severe deflections from the perpendicular, caused by abnormal stresses. Such stresses are frequently caused during frosts by the contraction of the wires. Where wooden poles are employed, in the very unlikely event of the breaking of all the wires on one side of a pole, the first pole on each side of the break would deflect, and each pole further on in either direction would deflect proportionately, thereby preventing any poles breaking and reducing the probable cost of repairs to a minimum. As soon as the line was repaired the poles would come back to their original positions. For further information upon the behaviour of poles under such conditions, reference may be made to Mr. Trotter's paper on overhead transmission, recently read before the Institution of Civil Engineers.

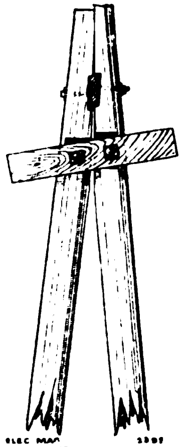

Fig. 7.

Iron poles, steel lattice masts, and reinforced concrete poles have been used for this class of work, but the author considers that in the event of a breakage, as mentioned above, they would not have sufficient flexibility to enable them to recover. Moreover, they would cost more to buy and erect, and would be much heavier and need better foundations than wooden ones. Again, iron or steel poles would need to be repainted at least once in three years, and, however much care was taken to preserve them, their corrosion would be so great that frequent renewals would be required, whereas a wooden pole, which had undergone an effective preserving process, will last for fifty years or more without attention. Creosoting has been generally adopted by the General Post Office, the National Telephone Company, the leading railway companies, and all large users, and gives general satisfaction.

It is most important in creosoted poles not to cut the treated surface if it can be avoided. Cutting away renders useless the most valuable part of the process, as the oil penetrates chiefly the outside or soft part—which is sapwood—of the timber, and any part which it is found necessary to cut after creosoting should be thoroughly tarred over.

It has often been asserted that wooden poles are unsuitable for certain climates such as prevail in East and West Africa, in parts of India, and elsewhere. The author believes that this is still an open question, and he has sent poles to those parts of the world to be tested, and hopes before long to be able to give some definite information on the subject.

The above paper was supplemented with an appendix by Prof. Goodman, in which the strength of poles is dealt with theoretically and a comparison of calculated results with the experimental results of the tests is made.

The Starting of Single-Phase Induction Motors.

A FAMILIAR method of starting single-phase induction motors from rest consists in the use of "phase-splitting" devices and auxiliary windings. Ordinarily such starting devices are designed for operation for only a short time, and if left too long in circuit with the motor become overheated. Moreover, when the motor is up to speed the efficiency is generally better if the devices are cut out of circuit. The following particulars of recent American patents are abstracted from *The Electrical World* and will be read with interest as showing the trend of improvement in this direction. The various methods described have been taken up by leading manufacturers.

A patent issued March 12 to Mr. A. E. Everest describes means for cutting out the starting circuits automatically when the proper speed has been reached. The mechanism is illustrated in Fig. 1, while its connection in the motor circuits is indicated in Fig. 2. The primary winding of the motor is of the three-phase type, and the starting circuits include the usual resistance and inductance shunted across the auxiliary phases. The point of connection between the resistance and inductance is joined to the third terminal of the motor through a plunger magnet winding of low impedance. Under starting conditions a large current passes through the magnet winding, but the current reduces almost to zero at a certain high speed. The magnet serves to hold the starting switch in its initial extreme closed position, until the magnet current reduces to a sufficiently low value, when a spring moves the switch lever automatically outward from engagement with the shorter contacts into the running position shown in Fig. 1.

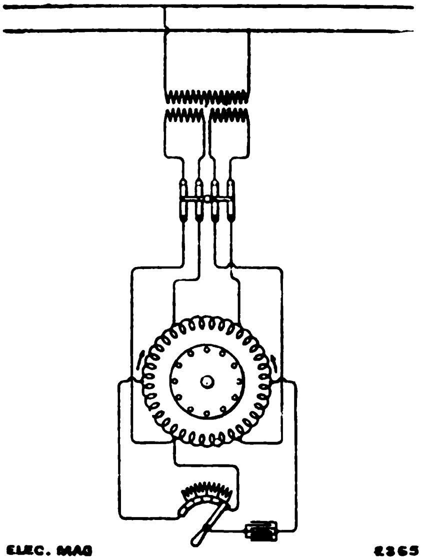

FIG. 3.

A method of using a condenser both for starting purposes and for improving the running conditions of a single-phase motor is disclosed in a patent issued March 12 to Mr E. J. Berg. The connections employed are illustrated in Fig. 3, where the condenser is arranged for starting. The switch in the condenser circuit allows the condenser connections to be shifted from 120 electrical space degrees displacement from the main winding at starting to 90 space degrees under running conditions, thereby improving the power factor and the efficiency. The least active portions of the primary windings of the motor are omitted from the main running circuits in

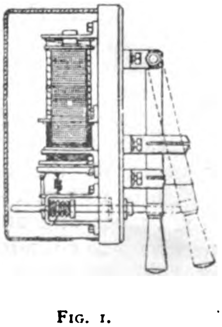

FIG. 1.

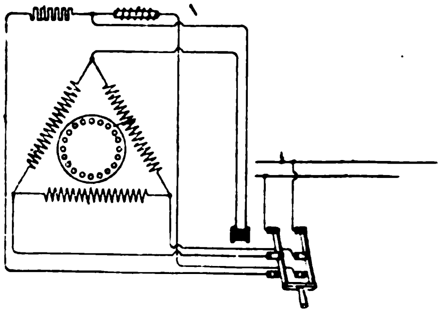

FIG. 2.

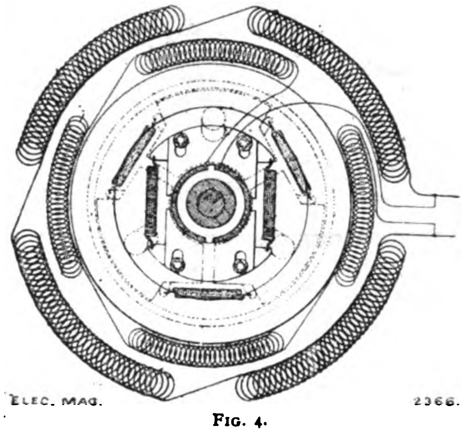

FIG. 4.

order to avoid any loss of power in them, but they assist in producing torque under starting conditions and contribute to the effectiveness of the condenser under running conditions.

Two patents, issued in February to C. R. Meston and H. I. Finch, disclose means for allowing the armature of a single-phase induction motor to accelerate from rest without being mechanically connected to the shaft and for automatically cutting out the starting coils and coupling the armature to the shaft when the proper speed has been reached. The motor is provided with an unsymmetrical two-phase stationary primary winding, consisting of the main coils and the starting coils. The secondary rotor winding is of the squirrel-cage type. The rotor is arranged to revolve freely on its shaft in attaining speed, and clutch devices are thrown into operative position when the desired speed is reached, and the rotor is coupled to the shaft by friction devices. The automatic coupling mechanism serves simultaneously to clamp the shaft and to cut out the starting coils when full speed is reached. The starting-coil circuit is completed through two segments of a divided contact-ring (Fig. 4) in contact with which are two plates attached to the coupling mechanism, which are thrown outward by centrifugal force at a certain predetermined speed somewhat below normal synchronism.

Electro-Hydraulic Excavating.

THE use of hydraulic methods for excavating earth has proved itself a most economical and efficient method where a good supply of water is available.

The process has been quite successfully utilized in Seattle, Wash., U.S.A., in connection with the excavating of the hilly section of that city.

Heretofore water has been secured for sluicing from the city water system, but owing to the recent large increase in demand upon the city plant, the municipal authorities have been compelled to discontinue the disposal of water for purposes other than those usually imposed upon such a system. It was owing to this condition that it was decided to install a sea-water pumping plant, taking water from Puget Sound at a point approximately 2500ft. distant from the point of consumption.

The plant, as described in *The Journal of Electricity, Power, and Gas*, consists of a 600kw., 2400-volt, 2-phase, 60-cycle, speed 327r.p.m., Westinghouse synchronous motor, carrying the rotor of a 40h.p., 440-volt, 2-phase induction-type starting-motor mounted on an extension of its shaft—the stator of the starting motor is bolted to a bracket carried on the main bearing pedestal of the large machine. The current is delivered at 2400 volts from the public supply company's system; the transformers for the starting motor being installed on the line pole outside the pump house.

The exciter is driven from a pulley mounted on the main shaft of the synchronous motor, and is controlled from the operating panel of the switchboard.

Power is transmitted to a 30in. four-stage Worthington turbine pump, through a friction clutch of special design, to the main driving pulley, which is belted to the pump pulley through the medium of a 48in. four-ply leather belt. The pulley ratio is such as to operate the pump at a speed of 500r.p.m. The belt tension is adjusted by raising or lowering an idler pulley placed about 12ft. from the pump pulley.

The pump has developed a capacity of 4000 gallons per minute against a gauge head equivalent to 430ft., and is capable of delivering water at the nozzle of a 6in. giant working at the highest elevation required at a pressure of 120lb. per square inch. The matter to be excavated consists largely of blue clay and is exceedingly tenacious and, in the ordinary way, difficult to move. However, no difficulty has been experienced in the present instance, and the plant has proved to be thoroughly satisfactory in every way.

A classified list of Traction and Transport articles will be found in the World's Electrical Literature section.

Motor-Generators versus Synchronous Converters,

With Special Reference to Operation on Long-distance Transmission Lines.*

P. M. LINCOLN.

General.

THE particular problem to be considered in this discussion is the following: Wanted, direct-current power of approximately constant voltage; for instance, for railways 500 to 700 volts, for an incandescent lighting system 100 to 275 volts, for an electrolytic process any direct-current voltage. Given as a source of power, a long-distance alternating-current transmission system, which may be either 25 or 60 cycles, may have a varying voltage at point of delivery, may have the variation occur either on account of the load taken by our particular station or independent thereof, and may have a somewhat variable frequency. Problem, what shall be used for making the desired transformation; synchronous converters? motor-generator sets with synchronous motors? or motor-generator sets with induction motors?

In this discussion a comparison will be made between these methods in regard to the following points, these points being placed, in the opinion of the author, in the order of their relative importance: reliability, voltage regulation, corrective effect, efficiency, cost, parallel operation, starting.

As a matter of simplification, it will be assumed that the line voltage is too high for a revolving machine and must be transformed before utilizing.

Reliability.

In this connection, the term "reliability" is taken to mean simply freedom from accident, or, in other words, capability of performing normal functions continuously without interruption. Without this element of reliability, it is evident that no plan of transformation can be a success. To those charged with the responsibility of the operation of such a plant, there will be no question but that this feature deserves the first place.

As to reliability, it is evident that the synchronous converter has a very decided advantage in that there is only one machine to get out of order, whereas either of the others involves two. Further, we are forced to use a low voltage on the synchronous converter so that its insulation is normally called upon to stand a maximum of not more than 700 volts; whereas with the motor-generator sets other conditions may dictate a very much higher motor voltage, and, therefore, a lower factor of safety in insulation. Both the synchronous converter and the synchronous motor-generator set suffer the disadvantage that a momentary removal of the voltage from their terminals—a short-circuit on the transmission line for instance—will cause them to drop out of step and make it necessary to start them over again. In this respect the induction motor-generator has an advantage in that it will resume operation automatically after such a temporary cessation of incoming power.

As to "bucking," this is a fault that is more commonly attributed to synchronous converters than to direct-current generators, but the reason for it is that the converter is more widely used under conditions that will cause "bucking" than is the direct-current generator. The usual cause is the sudden occurrence and removal of heavy overloads; as, for instance, when a circuit-breaker blows. The ideal conditions for this occur on the average interurban tramway, where the substations are relatively small compared with the maximum loads carried. A direct-current generator of the same size and exposed to the same conditions would probably give rise to about the same amount of "bucking." Exception is made in the case of the 60-cycle converter, which is admittedly somewhat more sensitive in this respect than the 25-cycle converter, chiefly on account of its necessarily short distance between brushes.

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* Paper opening Discussion by American Inst. Elec. Eng., New York, March 22, 1907.

As a relative comparison of the reliability of the methods under consideration in railway work, the following is advanced as a personal opinion. The number given indicates the relative number of hours that the apparatus would be out of service within a given time on account of defects inherent in the apparatus.

	Hours.
25-cycle synchronous converter	10
Induction motor-generator ...	14
Synchronous motor-generator	17

Voltage Regulation.

The term "voltage regulation" will be confined here to the changes that may take place in the direct-current voltage. The term embraces at least three distinct features:

a. Automatic change in voltage with change in load.

b. Ability to adjust the initial voltage.

c. Variations in direct-current voltage with variations in incoming line voltage and frequency.

Automatic Change in Voltage with Change in Load. In this respect all methods under discussion are equal. Rising or drooping characteristics of an adjustable value can be obtained with either the synchronous converter or the direct-current generator. The converter suffers the disadvantage that the power-factor of the current supplied must vary with varying loads, whereas with the motor-generator sets the direct-current voltage compounding adjustment is independent of the alternating-current circuit. This point will be further discussed under subsequent headings.

Ability to Adjust the Initial Voltage. It is in this respect that the synchronous converter suffers its greatest handicap. In the motor-generator sets the direct-current voltage is absolutely independent of the incoming alternating-current power. With the synchronous converter, on the other hand, the only way to adjust the direct-current voltage is to make a proportionate adjustment of its alternating-current voltage. There are several methods of accomplishing this end.

One method is to insert a reactance in the alternating-current circuit of the converter. By changing the field strength of the converter, adjustments of the voltage applied to the collector rings can be obtained within limits, depending upon the amount of reactance and available field adjustment. The disadvantage of this scheme is that the alternating-current voltage is thereby made interdependent upon the power-factor of the incoming alternating-current power, and that the high-tension line voltage is dependent upon the direct-current voltage adjustment to an extent depending upon the relative reactance in the transmission line and in the local converter circuit.

Another method is to use an alternating-current booster having the same number of poles as the converter, and mounted upon the same shaft. This is approaching motor-generator conditions, except that the generator involved has to take care of only a small percentage of the output of the set under consideration, and the range of voltage adjustment, instead of being from zero to the required amount, remains between limits depending upon the relative output of converter and booster. This really makes a more logical arrangement so far as initial voltage adjustment is concerned than the motor-generator, since adjustment down to zero is never required in practice. The maximum range of adjustment ever required is the range of incoming voltage fluctuations plus the initial range required.

Still another method is the use of taps on the transformer stepping down to the converter, or of an induction or other type of alternating-current voltage regulator. These in general have the same effect as the booster just described. The addition of any of these means of voltage regulation makes the converter equal to the motor-generator set as far as ability to adjust initial voltage is concerned.

Variations in Direct-current Voltage with Variations in Incoming Line Voltage and Frequency. The difference between the converter and the motor-generator set in this respect consists in the fact that the converter responds only to changes in the incoming voltage and the motor-generator only to changes in the incoming frequency. This last statement may be modified slightly by recognising that the slip of the induction motor depends upon the voltage, but the normal variations of voltage are so small that this feature can be safely neglected. For a given percentage change in incoming line voltage there will be an equal percentage change in the direct-current converter voltage. For a given percentage change in incoming line frequency there will be a greater percentage change, nearly double, in the direct-current voltage of a motor-generator set. However, changes in incoming line voltage will, under normal conditions, be much greater and sharper than those in frequency; so that in this respect the converter will probably suffer by comparison with the motor-generator.

There are cases where, on account of voltage regulation, a straight synchronous converter would be absolutely unusable, as, for instance, where a steady direct-current voltage for lighting is desired and the voltage of the alternating-current supply is varying due to causes other than the direct-current load under consideration.

Corrective Effect.

By "corrective effect" is meant in general the results that may be obtained in respect to the voltage regulation of a transmission line by means of a change in the power factor of the current taken. Only the synchronous motor and the synchronous converter need to be considered, since the power-factor of the induction motor is not adjustable.

It is desirable in any transmission line—

(*a*) That the voltage shall remain as nearly constant as possible independent of the variation of load, and

(*b*) That the voltage shall be capable of adjustment within limits at the will of the operator at any point.

So far as corrective effect is concerned, the synchronous motor has a distinct advantage over the synchronous converter in that the corrective effects may be obtained without involving the direct-current voltage. In the converter the corrective effect and the direct-current voltage are interdependent. On the other hand, when a converter is adjusted for a rising direct-current voltage characteristic, the tendency is to correct, in part at least, for the transmission-line drop caused by its own load. Thus it tends to fulfil condition (*a*) stated above. The synchronous motor can be made to fulfil condition (*a*) to the same extent by causing the direct-current generator current to flow through series coils on the motor field.

As to condition (*b*), both converter and motor-field can be so adjusted by hand as to accomplish this end, but in the case of the converter not without making a simultaneous adjustment in the direct-current voltage. In order to secure the same independence of action with converter as with synchronous motor, it is necessary to have some means of adjusting the converter alternating-current voltage independent of simultaneous power-factor adjustment; as, for instance, the synchronous booster or voltage regulator described under the previous heading.

There is another point of view that should be presented. A sub-station using the apparatus under discussion may or may not be under the control of the transmission-line operator. If it is, then its corrective effect can be used as transmission-line conditions may dictate. If it is not under his control the possession of corrective effect may not only be of no advantage, but also a positive menace to the proper voltage regulation of the line. If it is not under his control, he is probably better off with the induction motor-generator set, since it is neutral and possesses no power of changing line voltage at the caprice of an uncontrolled individual.

From the standpoint of corrective effect, therefore, the synchronous motor-generator has decidedly the advantage over the straight converter while the induction motor-generator is entirely neutral.

Efficiency.

At the end of a transmission line power is usually sold by the kilowatt-hour, or some other function that is proportional to it. The amount of the monthly bill will be proportional to the meter-reading, and the efficiency of the transformation therefore enters as a direct function in the cost of power. In this respect the converter has a decided advantage. It is a case of the losses in one machine as against those in two, and, moreover, the losses in the converter are somewhat less than in either element of the motor-generator set. The full-load efficiency of a converter of, say, 500kw. capacity, may be put approximately at 95 per cent., the synchronous motor-generator set 89 per cent., and the induction motor-generator set 88 per cent.

Cost.

Here again, as in efficiency, it is the cost of one machine against two; and the cost of the converter is not far different from that of each machine that goes to make up the motor-generator. An approximate idea of relative cost is given in the following:

	Per cent.
Synchronous converter	60
Synchronous motor-generator	100
Induction motor-generator	100

Parallel Operation.

The two points to consider in parallel operation are:

a. Proper division of direct-current load between units.

b. Proper operation so far as alternating-current ends are concerned, such as freedom from "hunting," &c.

As to division of direct-current load, there is no question either on direct-current generator or converters. In fact, it is perfectly possible by proper adjustment to operate converters and motor-generator sets of both kinds all in parallel.

As to operation on the alternating-current ends, the induction motor-generator is the least liable to trouble, since "hunting" or "pumping" cannot take place on that type of machine. The synchronous motor and the converter are on a par in regard to hunting. However, with the modern construction of synchronous machines, including as they do heavy dampers, there is so little probability of hunting that it may be entirely neglected. The only places in which this is apt to occur are in cases where antiquated generators are used and where the ohmic line drop is very high. Neither of these is apt to occur in practice.

Starting.

In starting the desirable features are:

a. Minimum draught of current from line of starting from alternating-current end.

b. Ease of synchronizing.

a. It is difficult to make any of the apparatus under discussion of such design that it will start readily from the alternating-current end. Good running characteristics invariably mean poor starting characteristics. The inherent starting characteristics of the synchronous motor and converter are bad on account of the large air-gap. The converter has the advantage of only having one-half the mass of the motor-generator to start. The induction motor-generator set has the advantage of better starting characteristics, but it suffers in comparison with the converter in having double the mass. If started from the collector rings, the converter suffers by liability of damage to commutator by burning and sparking. A draught of full-load current or less from the line is usually sufficient for starting any of the sets.

If it is essential to keep down starting current, a starting motor can be employed. In this case the converter again has the advantage of one-half the mass as well as one-half the losses of the motor-generator set. The same advantage applies to starting from the direct-current end, but is partly off-set in the converter by the shunting effect of the static transformers, if these be connected.

b. In synchronizing the induction motor has a great advantage in not requiring synchronizing at all. As between the converter and the synchronous motor, the converter suffers the disadvantage of having a commutator connected to the winding being synchronized, and, therefore, liable to injury by careless manipulation.

Altogether, there is not much choice in the starting qualities of the three methods, but what there is would cause them to be arranged in the following order: induction motor-generator; synchronous converter; synchronous motor-generator.

Summary.

On three of the preceding seven counts, namely, 1, 4, and 5, the converter has a distinct advantage.

On one more, 6, all methods are taken as being on a par.

On the remaining three, 2, 3, and 7, one of the other methods has the advantage. In one of these, 7, the disadvantage of the converter is not marked. The converter's disadvantage on the other two largely disappears with the addition of a means of voltage regulation.

This analysis, therefore, would seem to indicate that there are but few cases where the motor-generator should be used in preference to the synchronous converter.

Central Station Practice

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Meter Testing.

O. . BUSHNELL.

THE old chemical meters and fan-braked induction meters have been discarded for instruments which, with proper care, will give almost absolutely accurate results throughout their whole range. Meters which can run with such accuracy are naturally more delicate than their predecessors. Friction has been reduced to a minimum in their design and all the parts are carefully proportioned and adjusted. If such meters as these are to retain their accuracy, the bearings must be kept polished, the starting torque adjusted to local conditions, and all parts must be clean and free from dust.

As a result of these conditions, meter testing is a well-recognized branch of the work of up-to-date supply systems. There is hardly a central station manager who now questions the advisability of comparing customers' meters periodically with a reliable standard; the principle of the matter is well accepted, but when it comes to expending the money necessary for the work some are apt to be "penny wise and pound foolish."

Probably the most important point to be considered in connection with our subject is the frequency of the tests. As a matter of general policy, meters should not be run much longer than a year without testing, both as a protection to the company against loss, and as an assurance to their customers of the correctness of their bills. We cannot, however, arrive at the proper frequency of tests with any correctness without a study of the conditions which affect meter accuracy.

In all meters the revolving part is mounted on a jewelled bearing, which in time becomes rough; the permanent drag magnets are liable to change from ageing, rough handling, or short circuits; in commutator-type meters, the commutator and brushes will wear and become rough from sparking; lastly, all meters are influenced more or less by vibration, dampness, dust and other conditions of installation. Jewel wear, the first of these causes which affect meter accuracy, is influenced chiefly by the weight of the moving element, the number of revolutions of the spindle, and the degree of vibration present.

The first of these is constant for a given type of meter; the second is easily ascertained from the meter readings, and the influence of the last can be learned from successive tests.

Just how much wear a jewel will stand is somewhat uncertain. Sapphire, which is almost universally used, is of uneven structure, and variations in the quality of jewels cannot be eliminated by the most careful inspection in their manufacture. In a report on "Jewels and Pivots" in commutator meters, made a few years ago by the meter committee of the Association of Edison Illuminating Companies, it was suggested as a result of about 200 time tests that 800,000 revolutions be taken as the limit of wear of sapphire jewels in meters not subject to vibration, with half that number as the limit where vibration was constant. Since that time commutator-type meters have been very much improved. and in the latest type the weight of the moving element is only one-third as much as formerly. It does not appear that the decrease in jewel wear is directly proportional to the decrease in weight of the moving element, but it is probably nearly so. It would doubtless be more accurate to adopt a different limit of revolutions for each type of meter, in which the weight of the moving element is different, but for convenience 1,000,000 revolutions has been quite generally adopted as the limit of wear for sapphire jewels in all commutator meters.

The writer has not any direct data on the wear of sapphire jewels in induction meters, and here again the weight of the moving element varies in different types of meters; but from a comparison of these weights with those of the moving elements in commutator-type meters, and from the lesser number of jewels found defective in annual tests of induction meters, it is evident that a jewel will stand at least two or three times the number of revolutions in an induction meter that it will in a commutator type. The writer believes the limit of wear of 2,000,000 revolutions as adopted by a large supply company is certainly safe.

About two and a half years ago there was discovered a process of cupping diamond jewels for meters, and since then they have come into considerable use. One company has made tests of these jewels up to 9,500,000 revolutions without the stone showing any wear, but in some of the tests the shaft points became so flat as to introduce considerable friction. What the average life of the jewel is we cannot state, but believe that it can safely be taken at five times that of sapphire jewels, and that it is probably more than this.

Although the adoption of diamond jewels largely removes jewel troubles, the elements of magnet change, commutator friction and deterioration, due to local condition, still remain to be considered. These are so uncertain that they cannot be classified directly, and the old limits of registration between tests originally adopted for sapphire jewels have been adhered to quite generally among those companies which are using diamond jewels, on account of possible deterioration from these other causes.

There is an important factor also in meter construction to be considered in this connection, which makes the size of the meter an element to be considered in determining the frequency of tests. Meters of a given make have approximately the same full-load torque in all sizes. It follows that a meter of large capacity at times will operate necessarily with much less torque than a meter of small capacity, with a resultant increased liability to error. To illustrate, suppose a 5amp. 100-volt meter and a 50amp. 100-volt meter are both recording a load of one 50-watt lamp. The first is running on a 10 per cent. load, with 10 per cent. of its full-load torque, and the other on a 1 per cent. load, with only 1 per cent. of its full-load torque.

As the full-load torque of both meters is the same, it follows that the small meter has ten times as much torque on one lamp as the large one. Suppose also that it takes one-half of 1 per cent. of the full-load torque to overcome the friction of the bearings, the small capacity meter would run 5 per cent. slow, while the large capacity meter would run 50 per cent. slow on the 50-watt load. It is at once evident that meters of large capacity should be kept in better condition and more frequently tested than those of small capacity.

In accordance with the foregoing considerations, meters should be classified for testing somewhat as follows:—

First—A limit should be set within which all meters should be tested.

Second—A classification should be made according to sizes, so that the large meters will be tested oftener than the small ones.

Third—A classification should be made according to the work done by the meters, so that they will not be allowed to exceed a fixed number of revolutions between tests.

Fourth—Changes in classification should be made to allow for local conditions, as made evident by the results of successive tests.

In order to find out the methods now used in meter testing, the writer sent out a number of questions on the subject to twelve of the largest companies in the country. The first two were as follows:—

1. How often are your electricity meters tested?

2. On what basis is the frequency of tests determined?

Following are four of the answers received:—

First Answer.—1. By inspection once a year. 2. The basis of the frequency of tests is assumption that meters should be inspected at least once a year.

Second Answer.—1. From one month on largest meters to fifteen months on induction meters in residential districts, all meters coming, as a rule, within either one, three, six, nine, or twelve month classes. 2. On the basis of the work which the meter is doing, the intention being to test at every million revolutions of the disc in direct-current meters and every 2,000,000 revolutions in induction meters.

Third Answer.—1. As a general rule, once in twelve months; some are tested monthly, quarterly, and semi-annually. 2. The period is decided by the amount of the monthly registration, varying, of course, with the various sizes of meters. All meters tested more than once a year are equipped with diamond jewels. Our data show that a meter equipped with a diamond jewel need not be tested until it has made a million or more revolutions.

Fourth Answer.—Our meters are tested each time they are returned to meter shop, regardless of time they have been installed. Others that have been installed three years are changed, tested and cleaned up. We do not test meters on customers' premises unless requested to do so.

Commenting on these replies, the writer believes that the first system must result in the meters measuring the largest consumption showing the poorest accuracy.

The second tends to keep all meters on a level of accuracy at the same per cent. loads, but will result in a disproportionate loss from the large capacity meters on light loads.

The third system, which takes the size of the meter also into account, will not only keep up the accuracy of the meters under heavy service, but will also maintain the accuracy of the large capacity meters operating considerably under light load conditions.

The fourth system, the writer believes, is faulty both in allowing too long a time between tests, even for induction meters, and also in the method of testing, which will be taken up later.

The classification adopted by the writer about two years ago for commutator meters was as follows:—

Annual tests for meters of 5 to 10amp. capacity.

Semi-annual tests for meters of 15 to 50amp. capacity.

Quarterly tests for meters of 75amp. capacity and above.

Meters making over 1,000,000 revolutions of the disc between tests on above classification to be changed to more frequent class, so as not to exceed that number between tests, up to the quarterly class.

It has not been thought necessary to test any meter oftener than once in three months. Where a meter has not retained its calibration for this length of time, an investigation has been made. Such rapid loss of accuracy is usually found to be due to commutator trouble, caused either by excessive vibration or heavy momentary overloads. In the first case, the meter has been moved or mounted on a spring board, and in the latter a larger meter has been installed, with a better resultant accuracy than if the old meter had been left as it was and tested monthly. All meters tested quarterly have been equipped with cupped diamond jewels, and the semi-annual class are being so equipped as rapidly as they can be obtained.

A study of the data compiled from the tests made according to the foregoing schedule reveals some interesting facts. In the first place, the accuracy of the meters improves in an increasing ratio the more frequent the testing. The quarterly tests at one-half load show 15 per cent. more of the meters to be accurate than the annual tests, while the improvement shown by the light load tests, which are made at one-tenth load, is still more marked. The same increasing ratio of improvement the more frequent the testing is seen in the average accuracy obtained from these tests, which was as follows:

	One-half Load in per cent.	One-tenth Load in per cent
Annual tests	97.3	89.6
Semi-annual tests ...	97.8	90.8
Quarterly tests	99.1	96.5

An important showing from the data of the meters out of calibration is the ratio of the meters slow to those fast, which at one-half load was more than two to one, while at one-tenth load it was five to one. On still lighter loads, the ratio would doubtless be further largely increased. It was also shown by the data that the type "C" commutator meters maintained their accuracy much better than the older types with heavier moving elements, especially on light loads, where the greatest improvement was needed. A better accuracy was shown by the annual tests of type "C" meters than by the semi-annual tests of meters of the older types.

The writer has not given the above schedule, however, as a model, but rather as an illustration. In the light of the results obtained, he expects to make some changes for the coming year. It would seem as though some differences should be made in the classification of commutator meters as regards the type, though the use of diamond jewels in all the older types may largely obviate the necessity. In particular, however, it would doubtless be advantageous to test more of the meters quarterly, placing at least more of the meters of the older types in this class.

Induction meters have so far been classified by the writer on an annual basis for testing. Owing to the light weight of the moving element and the absence of commutator friction, these meters retain their accuracy much better than the commutator type. Data, compiled from about 14,000 annual tests, showed an accuracy almost identical with that of commutator meters, under quarterly testing. As it is probable, however, that the meters measuring the largest consumption are below the general average, it is expected the coming year to test the larger meters and those showing over 3,000,000 revolutions between tests on a semi-annual basis.

Having decided on some schedule for periodic testing, an important point to be next considered is the advisability of making installation tests. It is well known that meters transported some distance are liable to slight changes in calibration; also that direct-current meters, unless connected according to polarity markings, or even if so connected where influenced by magnetic fields from other conductors, will show some error on light loads. The questions sent out by the writer brought back the information that two of the largest companies in the country make a test on every meter installed before the first bill is rendered, notwithstanding the fact that the meters have previously been corrected in the testing room. In the Chicago Edison Company it has been the practice to have all meters after installation inspected, and cleaned and adjusted, if necessary, so as to run freely on a light load. In order to get some information as to the condition of meters after their installation, and as to whether an inspection or test is advisable, the writer made 100 tests of commutator meters and 100 tests of induction meters immediately after they were installed, these meters having all been adjusted in the shop before being sent out. The accuracy after installation, as shown by these tests, was rather disappointing, especially so in commutator meters on light loads. Tests were then made on an equal number of meters after the usual starting inspection. These tests showed a decidedly improved condition of these meters over the others, especially on light loads, and a better accuracy than that shown by any of the periodic tests. Still, there were some meters which showed a change of from 5 to 10 per cent. in their whole calibration. It is particularly desirable that the bills of a new customer should be absolutely correct. If a meter is slow for two or three months and then is corrected, it leads to the suspicion, when the bill goes up, that the company is increasing the bills arbitrarily after it feels sure that the customer will be permanent. The conclusion seems warrantable that both alternating-current and direct-current meters involving considerable consumption ought to be tested within one month after installation. The direct-current meters will be left in a more permanent condition if allowed to run for two weeks before testing, so that the commutator will have become oxidized. For the large class of small meters for offices, apartments, and houses, a careful inspection appears to be a sufficient safeguard. Perhaps a good division would be that meters which it is advisable to test oftener than once a year should have an installation test and others an inspection only.

The methods of testing should have some attention, which of necessity is very much abbreviated. The first important point is to have accurate standards. A laboratory standard voltmeter, a standard shunt and a precision-indicating wattmeter, make excellent working standards. These should be returned to the factory occasionally for calibration, unless the company has a laboratory where they can be checked. In the absence of these, a set of the working instruments should be kept for checking other instruments only, and returned to the factory for recalibration every six months.

Meters can be tested on the customer's premises or brought in and tested in the shop. Some have contended that the latter is the more accurate way, as conditions are more favourable for correct measurements. The necessity for installation tests, which is shown in a previous part of this paper, proves conclusively, however, that meters should be tested under local conditions in which they are to operate, and after all danger of change from transportation is over. Even if a meter is taken out and installed with the utmost care, so as not to disturb the original calibration in the slightest, frequently some change in the light-load adjustment is necessary to adapt it to local conditions of vibration or adjacent magnetic fields.

Four methods of testing are in general use:—

1. With ammeters, voltmeter, and stop-watch.
2. With calibrated resistance, voltmeter, and stop-watch.
3. With indicating wattmeter and stop-watch.
4. With check-recording wattmeter.

The first method is used only on direct-current work, and the second should be only so used unless the resistance is absolutely non-inductive. Self-contained shunt Weston ammeters, on account of temperature error, should not be used except in small sizes, and even then the current should be kept on the instrument only during the time necessary to make each test. Resistance shunts with negligible temperature coefficient milli-voltmeters should always be used for measuring large currents. The indicating wattmeter should be used only for alternating-current work, as it is not reliable on direct-current, owing to the influence of external magnetic fields. The check-recording wattmeter has the advantage of not requiring a stop-watch, yet if a portable load is used the inspector can tell the per cent. load on the meter with sufficient accuracy. An ordinary meter can be placed in a carrying box and used for checking, but it is better to use one of the special test meters, of which there are two or three kinds in the market. These meters are built with several field windings, so that the full torque of the meter is available at different loads. The meter under test can accordingly be tested with equal accuracy at heavy and light loads by connecting to the field coils of the corresponding capacity in the test meter. This method is particularly advantageous where a meter must be tested on a fluctuating load.

Each method of testing has its advantages, and each will be found best, doubtless, for some kinds of work. The writer has had all in use, and finds no particular advantage of one over the others in the amount of work which can be accomplished. He inclines to the belief, however, that the test meter with several field windings will soon have more general adoption and prove slightly more economical than other methods.

The number of meters which can be tested by an inspector in one day has been variously reported by the different companies from which data were secured at from six to ten. The writer believes an average of about seven should be obtained in testing commutator meters and eight or more in testing induction meters.

The use of diamond cupped jewels is recommended in all of the older type commutator meters where the jewel is subject to heavy wear. Sapphire jewels may be once repolished, but the stones should be removed from the screws and polished and inspected, the same as new stones, and set in new screws. If polished in the old setting some of the powder is apt to be left in the screw and cause trouble. Pivots also may be used a second time if they are carefully repointed and polished. A new pivot or shaft should always be inserted when a jewel is changed.

It is advisable to test meters at two points. The light load calibration is usually made at one-tenth load and heavy load at from one-half to full load. It makes no difference whether one-half or full load is used, as far as the final calibration of the meter is concerned, but the reports of the meters as found would doubtless show better on a full-load test. One-half load is used by the writer as being nearer the running condition of the meter. Whatever tests are made an accurate record should be kept and the results carefully tabulated. Only by an accurate knowledge of the condition of his meters and a study of the results of his testing can a central-station manager satisfy himself as to whether or not he is warranted in the expense he is incurring.—*Canadian Electrical News.*

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The Causes of Candle-Power Diminution in Frosted Lamps.

P. S. MILLAR.

DURING last year much discussion took place on the deteriorating effect of frosted bulbs as compared with clear glass for incandescent lamps. The writer has collected some data bearing upon the subject, and presents them in the form of an analysis of the cause of the candle-power deterioration, endeavouring to locate with at least approximate accuracy the extent to which the various factors contribute towards the net results. All data are obtained from tests of 16c.p. 3.1-watt carbon filament lamps. The tests include investigations of the following causes of candle-power deterioration:—

First.—Loss in candle-power due to increasing carbon deposit upon the inner surface of unfrosted lamp bulbs.

Second.—Increased loss in candle-power due to the same carbon deposit upon the inner surface of frosted bulbs.

Third.—Loss in candle-power due to dust and dirt upon the frosted surface.

The data on candle-power loss due to absorption by carbon deposit and to filament change in unfrosted lamps will be applied to frosted lamps. Warrant for this course lies in the fact that the resistance of the filament in unfrosted lamps varies throughout life substantially as does the resistance of the filament in frosted lamps. There is every reason to believe, therefore, that the filament change and resultant effects as determined in clear lamps may be applied without error in consideration of frosted lamp data.

Loss in Candle-Power Due to Blackening of Unfrosted Lamps.

The following lamps were selected for this test: Seven new lamps, five lamps whose candle-power had deteriorated 12 per cent. during 324 hours of burning, and twelve lamps whose candle-power had deteriorated 20 per cent. during 470 hours of burning

The bulbs of these twenty-four lamps were removed from their mountings. A tubular lamp of suitable dimensions was procured. Determinations of mean horizontal candle-power were made with the tubular lamp alone and again when the tubular lamp was placed inside of each of the bulbs in turn. From the results may be determined the loss of light due to the absorption of the carbon deposit and the glass wall. By a comparison of the results obtained from the three groups of lamp bulbs the loss due to increased density of the carbon deposit may be determined.

This comparison is valid because later determinations made by cleaning both the new and old lamp bulbs demonstrated that the absorption of light by the glass alone was substantially constant when considering the mean of the values for the three groups of lamps.

An alternative method which suggests itself is that of comparing the old lamp bulbs before and after removing the deposit of carbon. Results obtained in this manner are likely to lead to improper conclusions as to the increased absorption due to increasing deposit throughout life, because the bulb of the normal new lamp, which must be made the basis of comparison, already bears a slight coating of carbon, deposited during the manufacturing processes. A comparison made in this way would, therefore, lead to an exaggerated estimate of the deterioration in candle-power ascribable to increasing density of deposit.

The investigation was confined to the horizontal plane for the reason that it is general practice to determine deterioration in candle-power by measurements of mean horizontal candle-power. We are, therefore, concerned more with the loss of light in the horizontal plane about the lamp than we are with the actual loss of light in all directions, as would be determined by measurements of mean spherical candle-power.

Average results obtained from these three groups of lamps by the method outlined are as follows :

	Per Cent.
Absorption of glass and deposit of new lamps ..	5.0
" " " 88% " ..	11.7
" " " 80% " .	15.7
Loss due to increased absorption at 324 hours..	6.7
" " " " " 470 " ..	10.7

Deterioration in Candle-Power of Clear Bulb Lamps due to changes in the Filament.

It having been shown that in certain instances the deterioration in candle-power due to increasing density of carbon deposit upon the inner surface of the globe amounted to 6.7 per cent. at 324 hours, and to 10.7 per cent. at 470 hours, it is assumed that all other deterioration not so explained is due to changes in the filament. The extent of such effects would then be 5.8 per cent. at 324 hours and 10.5 per cent. at 470 hours. These values are obtained by eliminating from a standard life test performance curve the effects shown to have been due to increasing absorption by the carbon deposit.

Loss in Candle-Power Due to Increased Light Absorption by Carbon Deposit when the Bulb is Frosted.

The following method was adopted for determining this factor: Sixteen new clear lamps, 6 clear lamps whose candle-power had deteriorated 12 per cent. in 324 hours of burning, and 10 clear lamps whose candle-power had deteriorated 20 per cent. in 470 hours of burning, were selected. The mean spherical candle-power of each was determined. They were then acid frosted by the Sawyer-Man Electric Company, all under similar conditions, the lamps of each group being placed at one time in the same frosting rack, and the entire group being dipped as a unit. The results indicate the increased loss of light occasioned by the frosting upon the bulb of the two groups of lamps which had been burned for considerable periods.

Average Mean Spherical C.P. of 16 new lamps —clear	13.4
frosted	12.6
6 "88% lamps "—clear..	11.6
frosted	9.95
10 "80% lamps"—clear	10.6
frosted	8.6
Loss of light occasioned by frosting—new lamps	6%
" 88% lamps" (324 hours)	14.3%
" 80% lamps" (470 hours)	18.9%

These data indicate a loss of 8.3 per cent. at 324 hours and a loss of 12.9 per cent. at 470 hours, due undoubtedly to the action of the increasingly dense carbon deposit in absorbing a gradually increasing proportion of the light which the frosted surface reflects and diffuses internally.

Loss in Candle-Power due to Dust on the Frosted Surface.

The only tests of frosted lamps whose results are at the writer's disposal were made under conditions which made the soiling of the surface a factor to be considered. Consequently the lamp bulbs were not cleaned throughout the tests. Two tests of this kind may be referred to. In the first, twenty frosted lamps were burned for 290 hours; in the second, seven frosted lamps were burned for 336 hours. The loss of light due to the dust upon the frosted surfaces is shown in the following statements :

FIRST GROUP.

Average mean spherical candle-power at end of test	9.83
After washing	10.74
Loss due to dust	6.7%

SECOND GROUP.

Average mean spherical candle-power at end of test	8.4
After washing	9.5
Loss due to dust	10.5%

It will be understood, of course, that this factor depends largely upon local conditions and varies with the length of time during which the lamp is exposed rather than with the hours burned. As in the case of both tests referred to, the relation between the time the lamp is exposed and the length of time burned is practically constant; the latter is used. Figures showing loss of light due to dust are to be understood as applying to the particular cases under consideration only.

Application.

The accompanying illustration shows the points determined by test and shows curves which the writer has ventured to draw in order to apply the results of the investigation to a test case. In accordance with the best information available, the "useful" or "80 per cent." life (20 per cent. candle-power diminution from initial candle-power after frosting) of frosted lamps, when the bulbs are not cleaned during the test, is 240 hours. From the diagram, we derive the following factors as representative of conditions at 240 hours:

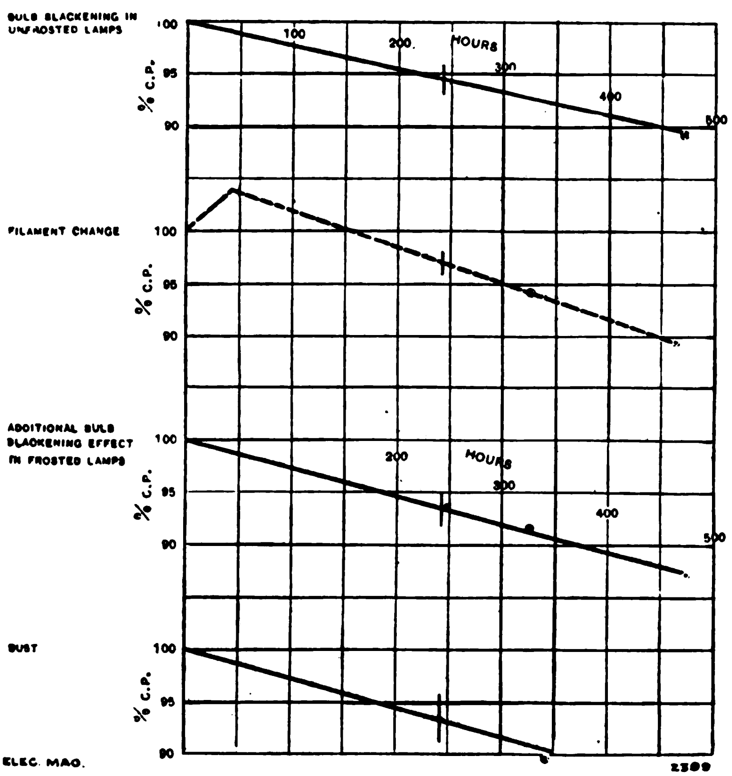
Candle-power diminution due to	Per cent.
Change in filament	2.9
Bulb blackening in unfrosted lamps	5.3
Additional absorption by deposit to which frosting subjects a portion of the light	6.5
Dust on surface of frosting	6.8

That is to say, change in the filament is responsible for a decrease to 97.1 per cent. of initial candle-power; the primary bulb blackening effect as in clear lamps further reduces the candle-power to 92.0 per cent. of initial; the additional absorption to which the frosting subjects a portion of the light still further reduces the candle-power to 86.9 per cent. of the initial value; and the dust factor occasions a final reduction to 80.1 per cent. of initial.

These data are derived from independent tests made at intervals throughout a period of 18 months. Applied in this rather crude manner, they cover the situation so thoroughly that no doubt remains as to the validity of the explanation which they offer for the relatively rapid decline in candle-power of frosted lamps.—*Electrical World.*

❧

[The following abstract is from a recent publication of tests made at the Bureau of Standards, Washington, U.S.A., also bearing upon the cause of the rapid diminution of candle-power of frosted incandescent lamps. It will be seen that the conclusions reached as the result of both series of tests practically agree with each other. The publication of the further researches of the Bureau of Standards on this important subject will be awaited with interest.]



CANDLE-POWER DIMINUTION IN FROSTED LAMPS.

The Short Life of Frosted Lamps.

E. P. HYDE.

It has long been recognized that the useful life of a frosted incandescent lamp, taken to 80 per cent. of its initial candle-power, is only a little more than one-half the life of a corresponding plain bulb lamp. The only explanation which has been advanced, so far as the writer knows, is that the temperature of the frosted lamp is higher, due to the increased absorption by the bulb, and that therefore the lamp reaches any given point in its life, *e.g.*, the 80 per cent. point, in a shorter time than that required for the corresponding plain bulb lamp.

Without entering, at present, into a discussion of the possible temperature effects, it is sufficient to notice that if the shortened useful life can be attributed to this cause, it is very probable that, due to the same cause, the total life of a frosted lamp up to the time when the filament burns out would also be very much less than that for the plain lamp. On the contrary, numerous tests indicate that if the life is taken to the time when the filament burns out, the average life of frosted lamps is the same as that for plain lamps.

It would therefore seem that some other explanation than that of the effect of temperature must be sought. A possible explanation of the phenomenon recently occurred to the writer, and was subjected to a test which showed conclusively that at least a large part of the effect, if not the entire effect, could be accounted for by the proposed explanation. A complete discussion of the investigation with the detailed numerical results obtained is to be published shortly in an extended paper on spherical reduction factors, and on the effect produced by plain and frosted bulbs of various shapes on the distribution of light around filaments of different forms. It was thought desirable, however, on account of the general interest in the question of the short useful life of frosted lamps, to publish this preliminary note outlining the explanation of the effect.

If we consider the case of a new plain bulb lamp, a certain small percentage of the total flux of light emitted by the incandescent filament is absorbed by the glass envelope surrounding the filament. When the lamp is frosted a relatively large part of the light which in the plain bulb would pass through the outer surface of the bulb is diffusely reflected back through the glass. In this way a relatively large part of the total flux of light passes through the glass more than once, and so the frosted bulbs show an absorption about 5 per cent. greater than that for the plain bulbs.

Now, the actual absorption coefficient of glass is quite small, so that it is readily seen that if in any way the absorption coefficient is increased appreciably, the apparent absorption due to frosting would be increased greatly. This is what happened when with increasing life the strongly absorbing carbon film is deposited on the inside of the bulb. The effect is the same as if the absorption coefficient of the glass had been increased greatly. In the case of an old plain lamp all the light passes through the carbon film once, the small percentage passes through twice, a still smaller percentage three times, and so on. When the lamp is frosted the percentage that passes through more than once is very much larger, and so the carbon film has an opportunity to absorb a much larger percentage of the total flux. According to this theory, although at any time the filament in the frosted bulb may be emitting the same total flux of light as that emitted by the filament in the plain bulb, the absorption of light in the carbon film is much greater in the one case than in the other, and so the apparent intensity of the frosted lamp at any time during life is less than that of the plain lamp, the difference in intensity increasing with the number of hours the lamps have burned.

In order to test the hypothesis in a rough way a frosted spherical diffusing globe was mounted on the photometer bench. At first a new four-candle-power lamp whose intensity was known was placed inside the globe, and the apparent absorption of the globe was measured. Then an old four-candle-power lamp on the inside of whose bulb a very perceptible deposit of carbon had formed was substituted for the new lamp. Measurements on this lamp showed a much larger apparent absorption of the frosted globe. Then the new lamp was coated with a layer of lacquer, which absorbed some of the light, and a third determination of the absorption of the globe was made. As before, the apparent absorption was greater than with the bare lamp.

In order to make a quantitative determination of the effect, ten comparatively new lamps and twelve old lamps that had dropped to eighty per cent. in candle-power were carefully measured for mean horizontal and mean spherical candle-power. They were then sent to a lamp factory and frosted by the acid process, care being exercised to see that the frosting was as nearly uniform for the different lamps as it was possible to obtain. The lamps were then returned to the Bureau of Standards and measured. The new lamps were found to have decreased in mean horizontal intensity by about four per cent. on the average, the individual lamps agreeing among themselves to within less than two per cent. On the other hand the older lamps were found to have decreased in mean horizontal intensity by eighteen per cent., or fourteen per cent. more than the new lamps. In other words, the apparent absorption of the frosting was approximately four and one-half times as great for the old lamps at the end of their useful life as for the new lamps. This means that if we were to assume no difference in the physical or mechanical properties of plain and frosted lamps, a lot of plain lamps which would decrease twenty per cent. in candle-power in a definite number of hours, would in the same number of hours decrease approximately thirty-two per cent. if they were first frosted. The useful life of the frosted lamps to eighty per cent. of initial candle-power would be about sixty or seventy per cent. of the useful life of the plain lamps, a value in approximate agreement with that commonly accepted. This shows that whatever effects may be produced in the lamps by frosting them, the mere absorption by the deposited carbon film, as explained above, is sufficient to account for a decrease in useful life of about thirty or forty per cent.

A single set of measurements of mean spherical intensity indicated that the new lamps had decreased about the same in mean spherical candle-power as in mean horizontal, whereas the old lamps had decreased several per cent. more in mean spherical intensity. This is probably due to the uneven distribution of the carbon on the inside of the bulb.

The following experiment has been planned to determine whether there are any other elements entering than that of the increased absorption of the carbon film due to internal reflections. A large number of carefully selected lamps will be accurately measured, of which twenty lamps will be burned to the "peak" point in the curve, twenty more to a point corresponding to about 60 per cent. of the normal useful life of the lamps, and forty more to the end of their useful life, measured to the 80 per cent. point. Twenty lamps will not be burned at all. All of the lamps, except twenty of those at the end of their useful life, will now be frosted at the same time and by the same process, and then all will be burned until the filaments break. In this way different points in the life curve can be reached by different paths. Thus, for example, it will be interesting to note whether the twenty lamps frosted at the end of their useful life will have the same average value as the twenty lamps frosted initially and then burned for a number of hours corresponding to the average useful life of the plain lamps. In this way it is hoped to determine whether any other elements enter to partly account for the relatively short useful life of frosted lamps.—*Elec. Rev., N. Y.*

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Progress in Electric Steel Furnaces.

The following are particulars of electric induction furnaces installed for commercial operation in Europe, as contained in an article recently published in *Electrochemical and Metallurgical Industry*:

Sheffield, England: Vickers, Sons & Maxim, 200kg.

Gysingen, Sweden: 150kw., 955kg. (20,000lb.). This is the original Kjellin furnace, reported on by the Canadian Commission.

Gurtnellen, Switzerland: International Calcium Company, 320kw.

Voelklingen, Germany: Roechling Works. Of the following four furnaces the first three are in operation, the fourth in course of construction. First, 50kw. to 75kw., capacity 110 to 130lb.; second, 110kw. to 120kw., capacity 660lb.; third, 736kw., pour 15 tons; fourth, a 150-ton mixer to keep the metal molten.

Essen, Germany: Krupp Works, 746kw.

Araga, Spain: 200kw.

There are further in course of construction a 300kw. to 400kw. furnace at Guldsmedshyttan, Sweden, and another furnace of the same capacity at Poldihütte.

From the above figures for the furnaces at Gysingen and Voelklingen the following interesting figures on the relation between capacity of furnace and required electric capacity are derived:

Capacity in kg. steel ..	50 to 60	300	955	15,000
Electric power in kw. ..	50 to 73	110 to 120	150	736
Approximate ratio of kw. to kg.	1	1·3	1·6	1·20

The chief point to be noted is that large-size electric steel furnaces, which enable a high economy of operation, are no longer only a possibility, but an established commercial fact.

TELEGRAPHY & TELEPHONY

For titles of all important Telegraph and Telephone articles of the month, see World's Electrical Literature Section.

Submarine Telegraphy.

On the 17th of last month, at the Royal Institution, Mr. Charles Bright, F.R.S.E., delighted his audience with a lecture on "Submarine Telegraphy." This was no text-book, dry-as-dust collection of technical data, but was a sound, easily understood dissertation on the problems and principles of practice framed in the romantic history of the subject. The numerous old-fashioned woodcuts projected on the screen enhanced the pleasure of the repetition of a story of early struggle and enterprise, familiar but ever-interesting to all of us. The quaint portraits of the pioneers of submarine telegraphy, taken half a century ago; the operating table of rough-hewn logs in a forest clearing; the fussy paddle steamboats engaged in laying the first Channel cable; the old *Agamemnon*, reminding one of Nelson's proud fleet, almost overturned in a storm with the weight of Atlantic cable aboard; and so on—all and each sustaining the romantic interest of the subject.

Mr. Bright opened his lecture with an apt quotation from Kipling:

On the great grey level plains of ooze; where
the shell-burred cables creep:
Here in the womb of the world—here on the
tie-ribs of earth—
Words, and the words of men, flicker and
flutter and beat.

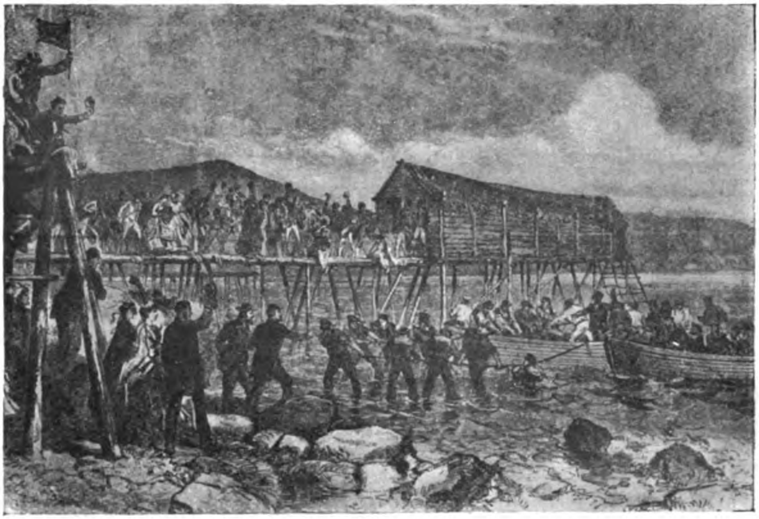
Having thus given a foretaste of joys to come, the author expressed his intention of serving the heavier part of his subject first, and proceeded at once to electric signalling and the Morse alphabet. In a popular style and with the aid of suitable illustrations, the working principles of telegraphy and the part played by electricity in this direction were admirably expressed.

There are, so to speak, various sorts of electricity. For instance, no doubt some of you are familiar with the sparks that can be produced from a frictional machine. Others of you will know what a bad time anyone may have if he handles two bare wires which form part of the circuit conveying a high-pressure current, whether for lighting, traction, or power purposes. But in telegraphy—the work to be done being of so delicate an order—we have nothing to do with electricity of the killing sort; and perhaps you will believe me when I tell you that by way of demonstrating the efficiency of one of the earliest Atlantic cables, just after its successful completion, a message was actually sent through by a battery consisting of a silver thimble containing a fragment of zinc, weighing a grain, and a few drops of pure sulphuric acid.

In ordinary practice we very generally use a few voltaic cells of the same type as are employed for working electric bells, the number varying from 5 to 100, according to the length, type, and condition of the line.

The siphon recorder was next described in some detail; the sending and recording of messages and the speed of the expert operator received attention. A brief insight into the principles of the automatic transmitter was followed by an explanation of duplex methods.

Duplex telegraphy, first applied to cables in 1870, is a system in which the output is nearly doubled, by sending and receiving messages from both ends at one and the same time. This system is adopted on all lines with a sufficiently large traffic to warrant its application, thereby tending to save the cost of an additional cable. This is a little too complicated for dealing with in detail here. The general principle is, however, that—by means of resistances and capacities corresponding to that of the cable itself—artificial establishment of an exact electrical balance at each end of the line is secured under normal conditions. This balance is then only upset in accordance with the transmission of signals, thus permitting these to be dispatched and received from either end at the same moment. The application of condensers at each end of the line, as well as other methods for curbing the current, also tends towards increased speed and greater clearness of signals. Thus an Atlantic cable of to-day designed to give a speed of 50 words per minute will practically work at a speed of 100 words a minute on the duplex system in conjunction with automatic (machine) transmission.



Landing the American End of the First Atlantic Cable.

Even the most proficient clerk can scarcely manipulate the transmitting key at a higher rate than 35 words to the minute; but the automatic transmitter is capable of any speed practically; and the receiving apparatus is nowadays almost limitless in its capacity. So much so that it is really only the line itself which governs the speed on an important ocean cable; and the electrical proportions of this can—within certain limits—be made practically anything in accordance with what the traffic warrants. Thus it will be seen that wireless telegraphy has something to compete with in the way of output. It should here be added that the working speed of a cable is dependent on its length; it is, in fact, inversely proportional to the square of that length; and it is for this reason that we have to provide a very much larger conductor and insulator for long than for short cables if we want to get the same high speed.

With a view to effecting automatic, instead of manual, translation between lengths of submarine line, the cable relay may be said to have been the dream of the cable manager for years and one that has seriously occupied the minds of many an electrician. Only comparatively recently, however, has complete success in this direction been achieved.

The question of cables, their conductors, insulation, and armouring occupied quite a considerable part of the lecture. The honour of having been the first to transmit current through an insulated wire is ascribed to a certain Baron Schilling.

In a paper read before the Imperial Academy of Science, at St. Petersburg, in December, 1859, Dr. Hamel mentions that in Sommering's note-book (which he had himself examined) he had found it stated that a General Wolzogen had told the said Sommering that he had seen an individual named Schilling explode mines in 1812 by a wire laid under the Neva.

This sounds rather like the information Sam Weller gave at the trial of Pickwick; and whether it be correct or not it is quite certain that Colonel Pasley of the Royal Engineers at Chatham sent a current through a wire under the Medway, and that he also blew up the wreck of the *Royal George* at Spithead in 1838 with a wire insulated with tarred rope and covered with an outer layer of pitched yarn.

Then Professor Wheatstone (afterwards Sir Charles Wheatsone), originally a music-seller, is said to have been actually engaged for three years from 1837 to 1840 on a method of insulation for a proposed cable across the Straits of Dover. In the latter year, however, Faraday and Werner Siemens independently pointed to the insulating properties of gutta percha; and india-rubber was suggested as an electrical insulator about the same time.

To Morse we must certainly give the credit for first *using* a wire covered with the latter material for transmitting signals under water. At this time the great American inventor was suffering from most dire poverty, and we find him writing: "I am crushed for want of means. My hat is hoary with age, and my stockings all want to see my mother." Nevertheless he succeeded in proving the utility of india-rubber covered wire for signalling across rivers.

A very complete description of the process of cable manufacture was given, the value of insulation being emphasized, and the various ways of securing mechanical protection being fully dealt with. Many samples and illustrations of cables as in actual use were exhibited. Here is part of the author's description of the progress of work.

On the upper floor of the factory is the drum of insulated conductor, and here are two jute-serving machines for applying yarns, each in opposite directions. On the floor below is the iron-sheathing machine ; here are different machines for applying the compound, cold first, then a layer of canvas tape, then hot compound, than another layer of tape with the reverse lay, then hot compound again, the cable finally passing under streams of cold water to cool and harden the surface before it is led to the cable-storage tank, on its way to which it receives a coating of whitewash to prevent sticking.

The splicing together of different lengths of the cable is performed in the same way as with ordinary hempen or iron ropes.

During the whole course of manufacture, the cable is kept under a continuous electrical test ; the instruments employed therein are similar in principle to those used in the subsequent electrical working of the line.

About thirty-five miles is an average output of cable made at a cable factory in an ordinary working day—varying, however, with the number of machines available. Thus, as a rule, it takes from two to three months to make an Atlantic cable.

The selection of route and the knowledge of the nature of the proposed submarine bed for the cable are all-important matters, and the neglect of complete methodical ocean surveys has occasioned many failures in submarine telegraph cables. Even when such surveys have been made and the route selected, it is necessary, whilst actually laying the cable, to take soundings at intervals of ten miles or so.

Besides measuring the depth, it is usual—by means of small metallic tubes fixed to the line—to secure a specimen of the bottom ; with the aid of a suitable thermometer, to ascertain the temperature, this also being a matter of some importance—partly in revealing the possible presence of any hot springs. Some may be surprised to know that the temperature at great depths is as low as 35 degrees Fahrenheit.

By far the most complete surveys of the ocean floor have been effected as the result of submarine cable enterprise rather than by the naval authorities of any country. This, however, is only natural ; for, in our case, a thorough survey often means the difference between heavy commercial loss and complete and lasting success.

The lecturer follows the finished cable from the factory tanks into the similar watertight tanks of the cable steamer, and describes the work of cable-laying. Here the subject was throughout dealt with in such a lucid and thorough manner that a lengthy abstract in the words of the lecturer is merited.

The cable is drawn out from the factory tanks into corresponding water-tight iron tanks on board—of which there may be three or four for different types and lengths of cable. The tank is furnished with a framework known as the "crinoline," and this is probably now the only crinoline in existence. Its object, in conjunction with the conical centre piece, is to steady the cable as it leaves the tank at a more or less high speed, and ensure it running out without accident.

With small repairing ships there is often no stern gear, any necessary laying work during repairs being effected by means of the bow machinery. Indeed, the picking-up gear is frequently used for paying out a short length even on large vessels, to save the operation of passing the cable along to the stern after splicing on to a buoyed end.

The evils of laying a cable without a proper knowledge of the contour of the sea bottom have already been dealt with, but it is almost equally bad to lay a cable without properly providing for such irregularities as are unavoidable.

This provision takes the form of laying what is described as slack cable where necessary ; that is, extra cable to fill up the said irregularities, thereby avoiding suspension from point to point. This involves a due regulation of the line in its egress from the ship in proportion to the speed of the vessel overground, and that is secured by the apparatus between the cable tank and the stern of the vessel.

Here followed a description of the Appold brake with its drum, around which the cable, on its way from the tank, takes several turns before passing to a sheave towards the stern of the ship. The speed at which the cable passes overboard is controlled by the speed of this drum. On the same shaft there are also two friction drums with adjustable brake straps. A further illustration was given showing the paying-out machinery aboard ship.

In this was to be seen the dynamometer, which consists, in principle, of a pulley which runs loosely in a vertical slot of the frame. The cable passes under this pulley; as the strain increases, the cable raises the movable pulley.

As the depth varies it becomes necessary to alter this strain by adjusting the weight on the brakes in order to pay out the amount of cable required for the irregularities of the bottom. It is obvious this must always be in excess of the distance run by the ship overground, which might be seven miles to eight miles of cable.

On a given line the average surplus cable laid to provide for the aforesaid irregularities of the bottom amounts to something like 10 per cent. of the length.

Thus, taking the distance across the North Atlantic Ocean at about 2000 miles, the cable actually laid will amount to 2200 miles. On this basis, and by continuous work day and night, it takes about three weeks to lay an Atlantic cable under favourable conditions as to weather, &c.

While the egress of the cable is being looked after by the engineers on deck, its electrical health is being carefully attended —its pulse carefully felt, indeed—by the electricians in the testing-room, who are—or should be—in continuous communication with those at the cable-testing hut on shore, where the paying-out vessel had laid the line from.

If anything goes wrong, such as the cable actually breaking under a strain, or the gutta percha insulation failing under the extreme pressure of the ocean, the electricians know of it at once, and their first duty is to give notice to the engineer-in-charge with a view to the ship being stopped and laying operations suspended.

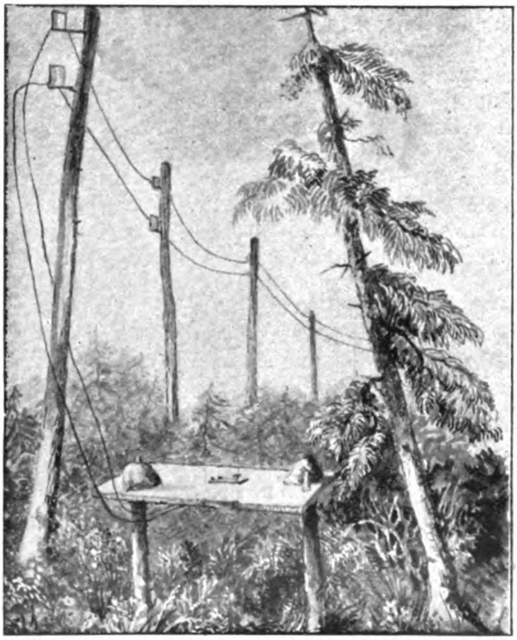
Electrical tests for the localization of a fault are too elaborate for dealing with on this occasion. The skill of electricians in this most important work has been brought to a very high pitch; and, under favourable conditions, a fault can be localized even to within a few feet—indeed, more accurately than the position of a ship can be determined. Under less favourable circumstances and on long lengths of cable—where tests may be seriously interfered with by earth currents—localisation is sometimes very difficult, though a fault is frequently localised within a quarter of a mile in a total length of 1000 miles.

A new joint and splice is made after the fault has been localised and cut out, or a new length of cable put in. Cable laying would then be continued—supposing that no further catastrophies took place—until reaching a point a few miles from the other shore, when the cable would be cut and buoyed preparatory to landing the cable at that end.

As a rule, however, the shore end has been previously landed by a smaller ship entirely occupied over this work; so that, in that case, the big vessel that has laid the main cable would approach the buoyed end of this shore cable.

As it would be impossible to haul a heavy cable ashore along the bed of the sea, it has to be floated ashore on the surface; and this is usually done by barrels, or preferably by india-rubber balloon buoys being attached to it at intervals.

The eventualities of a submarine cable are many. It may be torn by an anchor, crushed by a rock, or seriously damaged by a coral reef, such as abound in the tropics.



Newfoundland Telegraph Station, 1855.

Some of the growths often found on a cable tend to gradually decay the iron sheathing wires; then, again, a cable is sometimes severed by a sea-quake. It may be fatally attacked by a saw-fish or a sword-fish. But perhaps the little animal that make itself most objectionable from the cable engineer's standpoint is the insignificant-looking *Teredo navalis.* This little creature has a penchant for gutta-percha, and works its way there between the iron wires and between the serving yarns. The silica in the outer cable compound tends to defeat the teredo's efforts at making a meal off the core; and this defeat is further effected by the served core being enveloped in a thin taping of brass, applied spirally during the inner serving operation, and in a similar manner. But where the bottom is known to be badly infected with these little monsters of the deep, the insulator is often composed of india-rubber which has no attractions for the teredo, and possesses a toughness, moreover, which is less suited for its boring tool than the comparatively cheese-like gutta percha.

Faults occur in most cables from time to time. These require to be electrically localised from the cable testing hut, and a ship sent out to the supposed position to grapple for the line, pick it up, and effect the necessary repairs.

The lecturer exhibited several types of cable-grappling hooks and lines, including a specimen of the latter composed of strands of steel and hemp combined, and capable of withstanding a strain of as much as twenty tons.

When the cable has really been hooked and picked up—an operation which may entail several weeks, or even months, if only in waiting for favourable weather—the bight is secured at the bows and afterwards cut. Each end is then brought on board alternately and tested electrically. When found to be sound, the necessary repairs are effected, and the cable again returned to the deep. The lecturer, having described most of the operations connected with cable work, showed several views of worthy representatives of the telegraph fleet, which, by the way, amounts to fifty-four in all, including small repairing vessels. The *Colonia* is the latest of the big telegraph ships, having, with her sister ship, the *Anglia*, entirely outstripped all others in size and every other respect. This vessel and the *Anglia* were built for the laying of the All-British Pacific cable, which they laid in the year 1902 with complete success. With a length of 500ft. and a carrying capacity of 11,000 tons, either of them would be capable of laying an entire Atlantic cable with the assistance of a smaller vessel for landing the shore ends.

The Post Office telegraph ship, *Monarch*, of which a view was also shown, is concerned in the physical well-being of our telegraphic communications with our Irish and Continental neighbours by means of comparatively shoal-water cables.

After this followed an extremely interesting history of submarine telegraphy from the work of the earliest pioneers up to present practice, an account of which we are obliged to hold over to our next issue.

Telephonic Transmission Measurements.*

B. S. COHEN AND G. M. SHEPHERD.

THE study of telephonic transmission in scientific manner has advanced very considerably during the last few years. The necessity for increasing the range over which commercial speech is possible, due to the constant extension of the telephone into remote districts, and also the realization of the large expenditure involved in line construction and the consequent possibilities for economies, are undoubtedly responsible for this advance. For some time, however, the advance in transmission study has been mainly on the theoretical side, and investigators into the value of inserting inductances into telephone lines, such as Pupin, G. A. Campbell and Hayes, also Kennelly, have elaborated and put into workable form the original deductions of Oliver Heaviside on the transmission of alternating currents of variable frequency over telephone lines.

In order to apply in a practical manner the laws which govern the transmission of telephone waves, it is necessary to have fairly accurate quantitative information regarding the various factors concerned. The latest formulæ for calculating attenuation take into account practically all these factors, and have been proved to give solutions of most of the transmission problems met with in practice, but unfortunately very little is known as to the value of most of these factors.

As an example, what may be called the two fundamental factors in obtaining quantitative transmission results—viz., the average and highest important frequencies to be found in telephone speech waves, have been in the past more or less guessed at, and consequently very little information exists regarding many other factors which depend on them, such as line and apparatus impedances.

The acquisition of any absolutely accurate figures is a matter of extreme difficulty owing to the large number of variables existing, but an endeavour has been made by the authors to get data sufficiently accurate for practical application. This has been rendered possible as a result of the introduction of a number of instruments suitable for measuring the various attributes of telephone waves and lines.

(*To be continued.*)

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* Abstract of Paper read before The Institution of Electrical Engineers, London, May 9, 1907.

Every aspect of the design and manufacture of electrical apparatus is dealt with in this section month by month, and Engineers connected with large manufacturing concerns are especially invited to contribute.

The Practicability of Large Generators Wound for 20,000 Volts.*

B. A. BEHREND.

WITH the increased capacity of individual units of alternating-current generators it is natural that the potential for which these generators are wound should be continually increased. It commends itself to limit the current capacity of generators, as the distribution and conduction of large currents from the generators to the switchboards is cumbersome and expensive. Historically, the increase in voltage with the increased capacity of individual units and of power plants may be briefly summarized. The Niagara generators of approximately 3500kw. capacity, put into operation about ten years ago, were designed for 2200 volts. The 3500kw. generators of the Metropolitan Street Railway Company, of New York, were designed for 6600 volts. The 5000kw. generators installed in the stations of the Interborough Rapid Transit Company, in New York, were designed for 11,000 volts. The large generators for the Brooklyn Rapid Transit Company, of 7500kw., were designed for 11,000 volts also.

The question of the importance of higher voltages in future plants cannot be discussed without reference to prime movers. The four types of prime mover which are likely to be of great importance in the immediate future are:

1. The hydraulic turbine.
2. The gas engine.
3. The reciprocating steam engine.
4. The steam turbine.

1. The field of the hydraulic turbine for large capacities, that is, capacities of 7500kw. or above in individual units, is not likely to be of great importance at the present.

2. The gas engine has been successfully built for capacities up to 2000kw., and while it has unquestionably a great future for greater capacities, nothing as yet has been done to allow the application of the gas engine in connection with electric generators of 7500kw. or above.

3. The reciprocating steam engine still holds its own for small capacities, but for the capacities which we are here considering it has been superseded by the steam turbine.

4. The steam turbine in its present condition is pre-eminently adapted to large individual capacities. The author would consider a steam turbine of 7500kw. a comparatively small unit, and is firmly of the conviction that steam turbines of 10,000kw. or 15,000kw., and even of 25,000kw. will, before long, be developed and put into successful operation.

In thus looking to the steam turbine as the prime mover for generators of large capacity, we have limited our sphere of inquiry to generators of large capacity and high speed; namely, conditions as best fitted for the operation of steam turbines. The question of high voltage in generators of small capacity and driven by other prime movers than the steam turbine is referred to in the concluding paragraph.

Steam-Turbine Generators for Large Capacity, 7500kw. to 15,000kw. and above.

The difficulties encountered in winding generators for potentials of 20,000 volts or 25,000 volts are primarily mechanical difficulties. A coil containing a large num-

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* Paper opening Discussion by American Inst. Elect. Eng., New York, March 22, 1907.

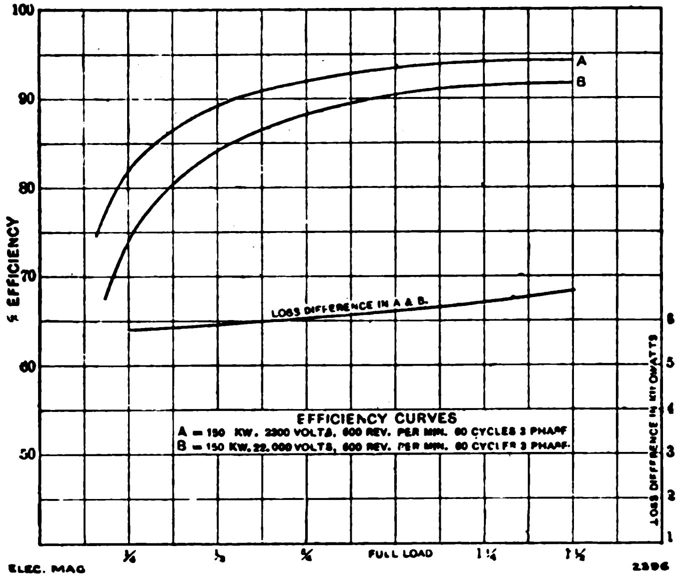


Fig. 1.

ber of small wires does not make a very mechanical piece of work. It would, therefore, appear desirable for the reasons here mentioned and some others, that the individual coils should consist of as few conductors as possible and that these conductors should be of such size as to enable the making of mechanically and electrically strong coils. Let us take a concrete example. A certain 7500kw. turbo-generator wound for 11,000 volts and operating at 750r.p.m. at 25 cycles has six conductors per slot. A 7500kw. generator wound for 22,000 volts, if designed along similar lines, would have twelve conductors per slot. Increasing the capacity of the generator from 7500kw. to 15,000kw. would enable the generator to be designed with six conductors per slot, and the difficulty produced by the higher voltage would be that of insulating the coils for the higher potential against earth and against one another.

The insulation of the coils against earth is easier to obtain than against one another. The question of insulating the coils from one another is particularly difficult in turbo-generators on account of the crammed conditions of the winding space, but at the present state of the art it is possible to obtain the necessary insulation for 22,000 volts, although this can be done only with considerable expense. As soon as there is a demand for large units wound for 22,000 volts, this demand will be met by machines carefully designed for these conditions.

The question of reliability of service is closely allied to that of quick repairs. It will be urged that not only is the danger of the breakdown of a 22,000-volt generator greater than that of a 11,000-volt generator, but also the repairs consequent upon a breakdown will be more difficult to make on the 22,000-volt generator. While this statement is perfectly true, a plan can readily be devised so as completely to de-

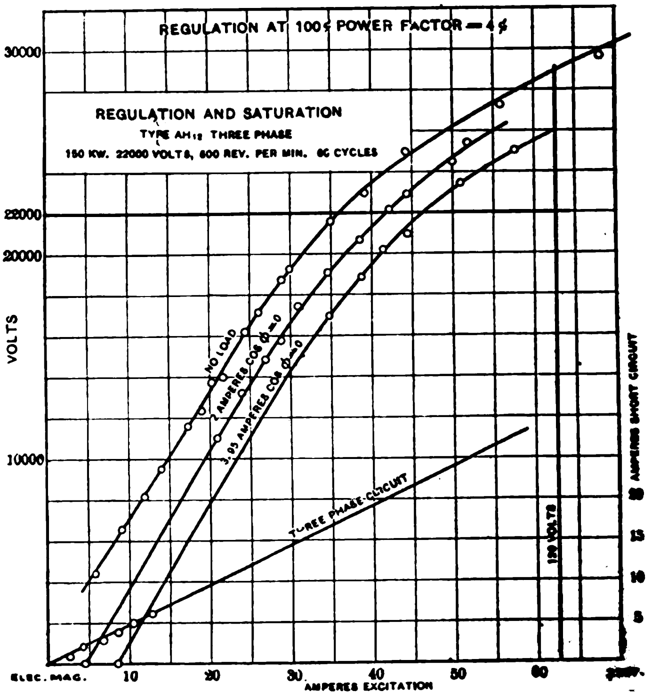


Fig. 2.

feat this argument. In a large power house in which a number of units of large capacity of the steam-turbine type are installed, the only rational way to make quick and satisfactory repairs consists in the carrying of spare parts. It will commend itself to the operators of power stations to carry a spare revolving field for one of these units and a complete set of spare armature coils. It must be insisted upon that the armature coils of these high potential generators can readily be replaced, and, unless the machines are designed to permit this, it would be necessary even to carry a spare stator completely wound which would be almost equivalent to having a spare unit in the power house.

Economy Obtained by the Use of Generators Wound Directly for 20,000 *Volts.*

The chief gains obtained by winding generators of large capacity directly for the high potential required for distribution consist in the simplification of the power plant, and probably in a slightly reduced first cost. The question of reduced cost should certainly be considered a very minor factor, as reliability of service should be the criterion either in favour of or against the adoption of generators wound directly for high potential. Calculations of relative cost are here omitted on that account.

Generators, Regardless of Size, for 20,000 *Volts.*

For the sake of ascertaining the feasibility of insulating coils for 25,000 volts, the author has had in operation a 150kw. generator wound for 25,000 volts, 60 cycles, 600r.p.m. This generator has been in operation for months, working day and night under full load. Regulation curves and other data are illustrated in the accompanying diagrams. There is no doubt that there may be a limited field for units of small capacity wound for potentials above 11,000 volts, and the object of this paper is to call the attention of the engineering profession to the feasibility of generators of as small capacity as 150kw., being wound for as high a potential as 25,000 volts. That the regulation, the heating, and the efficiency of this machine are very satisfactory is amply shown by the curves accompanying this paper. Should such machines be used in the future, it must always be insisted upon that the exchange of coils can be effected readily. In the 150kw. generator referred to, it has so far not been necessary to replace any of the coils on account of defective insulation.

Summary.

Where individual units of very large capacity are installed in power plants, a potential of 20,000 volts is feasible, and it is to be recommended in units of 10,000kw. capacity and above.

Where individual units of small capacity are needed for a potential of 20,000 volts, the conditions can be met in most cases, even down to capacities of 150kw.

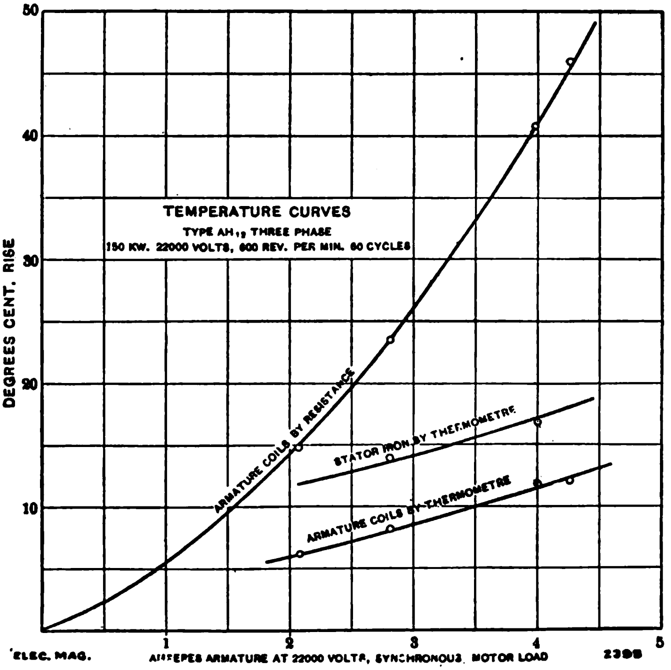
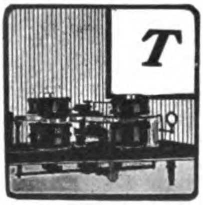


FIG. 3.

ELECTRO-CHEMISTRY, Electro-Physics and ELECTRO-METALLURGY

Titles to all important articles on the subjects covered by this section will be found in the World's Electrical Literature Section.

Fixation of Atmospheric Nitrogen.



THE fixation of atmospheric nitrogen and the application of the products thereby obtained was the subject of a very able paper presented some time ago before the Berlin Electrical Society, by Dr. Georg Erlwein, chief engineer of the electro-chemical department of the Siemens & Halske Company. The author has been interested in work of this kind for his company for the last sixteen years.

His full paper may be found in the issues of January 10 and 17, 1907, of *Elektrotechnische Zeitschrift*. In the introduction some preliminary researches are briefly mentioned which were made by Werner von Siemens in 1889 in collaboration with A. W. von Hoffmann; further investigations by O. Frölich and G. Erlwein on the electric production of ammonium nitrate; and the researches of Crookes and Lord Rayleigh, Bradley and Lovejoy, Birkeland, Kowalsky, Pauling. The author also named the following chemical manufacturing companies as having been or being interested in work of this nature: Salpetersäure Industrie Gesellschaft in Gelsenkirchen, Westdeutsche Thomasphosphat Werke, Badische Anilin- und Sodafabrik in Ludwigshafen.

Siemens & Halske took up the problem again in 1902. The starting point of their new researches was the experience which they had gained in the development of the flame arc lamp, in which the arc carbons are impregnated with certain salts, among them, salts of rare earths and fluorspar. When these salts evaporate into the arc the arc is lengthened and its zone of reaction becomes more effective. Under proper conditions of the experiment, including a blowing magnet acting on the arc and increasing its surface, the effect becomes surprising. The arrangement used by Siemens & Halske in 1902 consisted of a cylindrical space supplied with compressed air, enclosing an arc produced between impregnated thick carbon electrodes or cooled metallic electrodes, and the surface of this arc greatly increased by the use of a blowing magnet. Later on, in 1904, a second method was tried, based on the action of the horn lightning arrester. Between parallel or diverging vertical electrodes, which had a length of several metres and which were placed in closed porcelain or clay tubes, arcs were started at the bottom, which then travelling upwards continually increased their surface, and were finally broken, the speed being easily adjustable. Neither of these two methods has yet been developed into an industrial process which would be sufficiently cheap.

Some notes were given by the author on the efficiency of various systems employing electric discharges through air, and it was said that even with the best efficiencies now obtained only 3 per cent. of the electrical energy is utilised for the oxidation of the nitrogen or the formation of nitric acid proper, while the balance of 97 per cent. is consumed mainly in heating the gases required for the reaction as well as the excess of air.

As to the commercial importance which may be attained in future by processes using electric discharges through air, Dr. Erlwein thinks we can give a definite answer only after the lapse of some more years.

A second group of processes is based on the facts known since Wöhler and Deville, that certain metals and metalloids, like silicon and boron, when heated with nitrogen, form nitrides, and that these nitrides when treated with steam again decompose with evolution of ammonia. Technical experiments in this direction on a larger scale have been made by Marguerite, Sourdeval, Mond, and Solvay, and also by Friedrich Siemens, who worked together with Dr. Obach on this subject at the end of the seventies in Dresden. Siemens' first experiments were not very encouraging, but they were useful in so far as they decided several questionable points.

The Siemens & Halske Co. took these researches up again in 1897 in connection with Dr. Mehner and Director Schlutius, of the Westdeutsche Thomasphosphat-Werke and later with the Gold- und Silber-Scheideanstalt in Frankfurt. Instead of boron nitride (employed in the original experiments) the nitrogen-compounds of sodium were employed, in the first place cyanides. These cyanides in the new experiments were equivalent to the nitrides in the older experiments in so far as they were not intended to be the final product, but were to be decomposed with overheated steam to yield ammonia.

In the old empty Grabau aluminium factory in Trotha, where a 500h.p. steam dynamo was available, a process was tried for a considerable time, which had been patented by Dr. Mehner for manufacture of cyanide and ammonia. The process was based on older work of Mond. The results obtained were, however, not sufficiently promising from a commercial point of view. Cylindrical furnaces of 6 metres height and 1 metre diameter were used, which were charged with sodium carbonate and coke. By means of generator gas as source of nitrogen, it was intended to produce first cyanides and to decompose them then at a suitable place of the furnace by treatment with overheated steam so as to get ammonia. In the latter reaction sodium carbonate would be regenerated and was to be used over again together with coke for a new charge of the furnace. The gases of reaction which would be generated during the whole process, and which contained a very high percentage of carbon monoxide, were intended to be used in gas engines after the ammonia had been recovered in scrubbers.

A third group of processes is related to the manufacture of calcium carbide. The outcome of the work in this direction is the manufacture of calcium cyanamide, which is now commercially successful on a large scale. Dr. Erlwein gave an historical review of the development of the process, mentioning the names Frank, Caro, Rothe, Pfleger, Freudenberg, Frank, Jr., Wagner, Gerlach, Erlwein. The Gold- und Silber-Scheideanstalt of Frankfurt (the leader of the cyanide syndicate) was first associated with Siemens & Halske in this work, but dropped out later on account of the weak cyanide market at the time of the Boer War. Siemens & Halske then decided not to interest themselves any longer at that time in the production of cyanide from cyanamide, but to stop with the production of cyanamide and to sell it for fertilising purposes.

Dr. Erlwein states that the process of changing the cyanamide into cyanide has been fully worked out, and will soon be the basis of a new cyanide undertaking, since the cyanide market is now in a much better condition.

Concerning the principles of making calcium cyanamide either from calcium carbide and nitrogen (Frank-Caro process), or from lime, coke, and nitrogen (Erlwein or Siemens-Halske process), the description of the furnaces for these processes as given in Dr. Erlwein's paper appears to contain information hitherto unpublished.

The Erlwein process with lime, coke, and nitrogen as raw materials, and employing the reaction $CaO + 2C + 2N = CaCN_2 + CO$ was first cheaper than the Frank process, starting with carbide and nitrogen, as long as the carbide was high in price. The Erlwein process was carried out in electric furnaces similar in form to the Acheson type of furnace. They were 6 metres long, 3 metres wide, and 3 metres high, and had double walls so that the nitrogen could be introduced under pressure into the furnace. An exit was provided for the carbon monoxide gas.

Between the ends of the thick carbon electrodes a thin carbon rod was inserted. When the reaction started, this thin carbon rod first became incandescent, and calcium cyanamide formed in concentric layers around it. After completion of the run, the cyanamide could be removed in the form of a porous cylinder.

When this process had been developed, the excessive calcium carbide boom in Europe had led to the inevitable crash, and the price of carbide had fallen very essentially. Now it was found that the Frank process, starting with carbide, was the cheaper one, and it was developed to a commercial success; its fundamental reaction is

$$CaC_2 + N_2 = CaCN_2 + C.$$

The most important apparatus for the cyanamide process are those for making pure nitrogen from air and the cyanamide furnaces. To make pure nitrogen from air, either retorts containing copper may be used or the atmospheric air may first be liquefied by the Linde process by means of strong pressure and cooling down to -194° C. and the liquid air then separated into nitrogen and oxygen by fractional distillation in apparatus of the kind used in alcohol stills. The cyanamide furnace consists of a coal-fired furnace in which retorts are placed, closed air-tight and filled with powdered carbide to a certain height. They are heated to red or white heat, and nitrogen gas is introduced into the furnace. Under these conditions, the carbide eagerly absorbs the nitrogen; this is an exothermic process, and the heat evolved accelerates the reaction. When the gasometer in the gas-supply pipe shows that the carbide does no longer absorb nitrogen, the incandescent cyanamide is removed from the retorts, cooled under absence of air, powdered and packed for shipping.

The cost of making calcium cyanamide depends on the cost of making pure nitrogen from air and on the price of calcium carbide, which is again determined by the price of the electric power. Carbide factories which pay £2 to £3 per h.p.-year and pay otherwise normal prices for lime, coke and electrodes and average wages, may be sure to make a good profit by working their carbide into cyanamide, even if the price per kg. of nitrogen in the competing Chili saltpetre or ammonium sulphate (which is about 1s. 6d. and 1s. 4d. respectively at present) drops considerably below the present market price. They are especially enabled to make profits if they have at the same time cheap power for operating a Linde plant, which according to the size of the apparatus and according to the cost of power of .25d. to .4d. per kw.-hour, is able to produce pure nitrogen from air in continuous operation for .4d. to .7d. per cubic metre.

Since modern and well-conducted carbide factories produce about 2 tons of carbide per kw.-year, and since 2 tons of carbide absorb about 500kg. of nitrogen to form cyanamide, the fixation of 1 ton of nitrogen requires an expenditure of power of 2kw.-years. This figure is interesting if compared with the energy required for binding 1 ton of nitrogen by processes using electric discharges through air for the purpose of making nitric acid, where even with the best efficiencies about 6.4kw.-years are required.

The commercial calcium cyanamide (Kalk-Stickstoff) is a black powder, stable in air, and consists of about 57 per cent. of calcium cyanamide, 14 per cent. of free carbon (which gives the black colour), 21 per cent. caustic lime, 2.5 per cent. of silicic acid, 4 per cent. of iron oxide, and small quantities of sulphur, phosphorus and carbonic acid. The average content of nitrogen is 20 per cent.

When put into water, calcium cyanamide dissolves, but decomposes quickly (especially in hot water), yielding caustic lime, and, with polymerisation, a complicated compound called dicyanamide.

When treated with overheated steam, calcium cyanamide gives off its nitrogen quantitatively in form of ammonia.

Treated with acids in aqueous solution a number of highly interesting organic compounds are obtained under certain conditions. Among these products is urea.

When melted with sodium carbonate, sodium chloride, or other materials, the whole nitrogen in the cyanamide is changed into cyanide-nitrogen and the product when cooled consists of a mixture of calcium cyanide, sodium cyanide and the products of the decomposition of the added material.

Dr. Erlwein finally discusses briefly the practical applications of calcium cyanamide.

1. Cyanamide may be used directly as a fertilizer in agriculture. Those who are interested in the agricultural side of the problem will find interesting comparative pictures of the growth of plants under the fertilizing action of Chili saltpetre and calcium cyanamide, &c., in the original German paper.

2. Calcium cyanamide may be used for the production of ammonium sulphate, which is also consumed in large quantities for fertilizing purposes. The reaction yielding ammonia is $CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$. It may be useful to provide such ammonium sulphate factories as an addition

to cyanamide factories in order to take care of the over-production.

3. Cyanamide may be used for the manufacture of dicyandiamide, a compound used in the manufacture of aniline colours and gunpowder. By suitable leaching with water and crystallization, this compound is obtained in form of pretty white crystals. The chemical equation is

$$2CaCN_2 + 4H_2O = 2Ca(OH)_2 + (CNNH_2)_2.$$

4. Cyanamide may be used as starting material for the commercial manufacture of sodium cyanide or potassium cyanide. According to a process devised by Freudenberg, the calcium cyanamide is melted with sodium chloride in excess and is thereby transformed almost completely into sodium cyanide. The product obtained in this way, which contains about 22 to 23 per cent. of sodium cyanide (corresponding to 30 per cent. of potassium cyanide) is either sold directly in this form as so-called "sodium-cyanide substitute" (Cyannatrium-Surrogat) for use in gold metallurgy or is worked up into chemically pure sodium cyanide or potassium cyanide. Both brands will be made on a commercial scale as soon as a new factory is completed which is in course of erection near Berlin.

5. As a hardening material for iron and steel, calcium cyanamide has found a new sphere of application. This application is due to the ability of cyanamide to give off carbon to the iron which is thereby hardened. This ability is enhanced by the addition of other compounds to the cyanamide, and this product is now sold under the trade name of "Ferrodur." Dr. Reininger, chief chemist of the well-known tool-steel and machine works of Ludwig Loewe, first recognised this property of cyanamide, and called attention to the extremely uniform action of this new hardening material, which proves useful especially at such temperatures at which a uniform introduction of carbon into iron heretofore met with difficulties.

6. For the manufacture of urea a small plant is already in operation in which the calcium cyanamide is treated in a suitable way with acids and immediately changed into solutions of urea, which may be easily crystallized.—*Elec. Chem. and Met. Ind.*

Electrolysis in Ferro-Concrete.

THE question has often been raised lately as to whether, under certain conditions, the steel of reinforced concrete may not be subject to the destructive effects of electrolysis. Some experiments, as follows, were recently reported by Mr. A. A. Knudson to the American Institute of Electrical Engineers.

Blocks of one-to-one Portland cement sand concrete were moulded in a common metal water pail, with a piece of 2in. wrought-iron pipe placed vertically within the blocks to a depth of about 8in. When the blocks were three years old, one of them was placed in a tank of sea water, and another in a tank of fresh water, and direct current was fed to the embedded pipes, the negative electrode consisting of a piece of sheet iron placed in the tank. A third block, similar to the other two, was placed in a tank of sea water but was not subjected to the electric current. After a period of thirty days the last-named block was found to be in perfect condition and the pipe was perfectly bright. But the two other blocks, which had developed cracks during the test, were easily broken open; yellowish deposits were found in the cracks, where the concrete had deteriorated to such a degree that it could be cut easily with a knife; and the pipes were considerably corroded, showing a loss of weight of over 2 per cent. Similar results were obtained in tests with blocks of standard Rosendale cement, made in the same mould, although in this case the blocks were tested thirty days after they had been made. The cracking of the concrete appeared as early as the sixth day of the test, and by the eighteenth day they looked as though they might fall apart.

It cannot be denied that these results are of profound significance. They call for careful investigation on the part of concrete engineers, and the provision of special means of insulation in all cases where imbedded structural steel, or the reinforcing material of armoured concrete, is liable to attack by stray currents in the neighbourhood of wet foundations.

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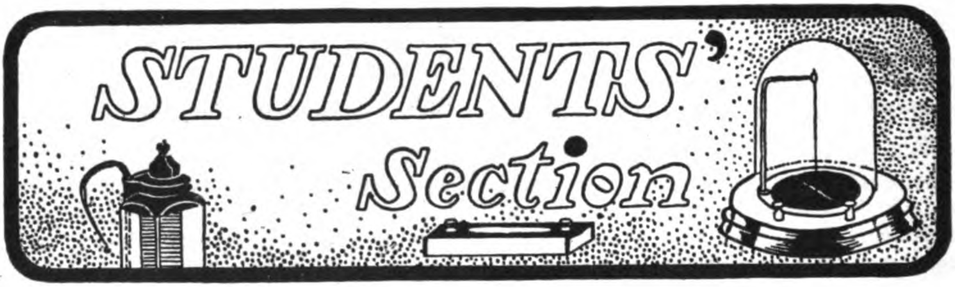

Students should refer to the World's Electrical Literature Section for classified list of articles of special interest to them.

The Manufacture of Rubber-Insulated Wire.

H. T. WREAKS.

THERE are practically eight separate processes in rubber-covered wire manufacture, as follows: Tinning; mixing of compounds; insulating; vulcanizing; braiding; waxing; finishing; and testing.

Tinning.—After copper has been selected of requisite size; in some cases it is taken with a little over the required diameter, and put through rolls to reduce to exact size, the first step in the process of rubber-covered wire is the tinning. This is accomplished by running the copper through an acid bath and then through a melted tin bath.

Tinning is necessary on account of free sulphur remaining in the insulation compound, which sulphur has a great affinity for copper, but has practically none for tin. The tinned wire is washed and wiped to leave same perfectly smooth.

Mixing of Compounds.—This is purely a mechanical process and consists in passing the pure rubber, reclaimed rubber, shoddy, sulphur, dry mineral matter, extra resinous matter, or other substances which might be used in the compound, through steel rolls revolving in opposite directions until all the materials are mixed into an entirely homogeneous mass; care of course being taken that the rubber or shoddy substances have been thoroughly cleaned and the other substances thoroughly screened from any material or foreign substance which would spoil the consistency of the compound.

Insulating.—The next process is the insulating process, of which there are two: the seam process and the seamless process.

In the former process, sheets of rubber cloth are passed through specially grooved rolls, through the centre of which the wire to be insulated runs, and these sheets are pressed tightly around the wire and locked together by means of a seam automatically formed by the rolls by folding one edge of each the upper and lower sheets of rubber cloth into each other.

These sheets are made by a calendering machine, consisting of three parallel steel rolls, revolving in opposite directions, through the upper two of which a special cloth is run and through the lower two of which is passed the rubber compound, and by revolving the rolls the compound is thoroughly worked into the cloth, until the latter becomes a sheet of rubber cloth.

The seamless process consists of forcing the compound while in a soft state through a hole equal to the intended outside diameter of the insulation on the wire being made up and through the centre of which hole passes the copper wire to be insulated. This is done by means of a hollow screw, the rotating of which forces the compound out through the hole, the copper wire being fed forward at a predetermined rate of speed.

Vulcanizing.—Consists of the application of heat to a compound containing sufficient sulphur to change the mixture from a putty-like, pliable mass, to a hard, more or less elastic, substance.

There appears to be considerable divergence in practice as to length of time and temperature at which vulcanization produces the best results; much of this difference being probably due to the varying natures of the compound, some to question of factory cost and other reasons.

This time and temperature varies from two hours to forty minutes and from vacuum boiling point to 280deg., steam heat being used.

Braiding.—This process sometimes comes before and sometimes after vulcanizing, and probably varies less than other processes in making up rubber-covered wire, except as to size of yarn used and closeness of weave.

Both double and single braid are applied from one machine, the wire moving down through the centre of machine while the different bobbins wrap their threads around the outside. Sometimes the double braid is put on by running wires through two single braiders.

Waxing.—This is done by drawing the braided vulcanized wire through solution containing wax, ozokorite, mineral wax, or other substances of a moisture-repellant nature; this solution being hot enough to, more or less, thoroughly impregnate the braid and fill the interstices between the braid so as to protect the wire from moisture, oxidization of rubber compound, &c. The waxing solution is usually about 240deg. F., but varies with nature of solution, the temperature being adjusted to make a freely flowing fluid.

Finishing.—This consists in passing the wire through cloths, ropes, &c., so as to completely smooth down the outside and present a good appearing finish. A waxing solution at a lower temperature is also used for this work.

Testing.—Tests can be classified broadly under three heads: physical, chemical, and electrical, and, as the product tested is of value only on account of its insulating qualities, the electrical tests will be conceded, without argument, to be the most valuable, the function of the physical and chemical tests being more to determine the nature of the ingredients used in making up the compound, although, of course, being important to the extent that the life of the compound would be determined by the kind and quality of material used in it.

Unfortunately, however, in the desire for quick results the question of life of insulation has not heretofore always received the commercial consideration to which its importance entitles it, and, in the absence of sufficient data to determine what mixture of ingredients produces the longest life of insulation, the values of physical and chemical tests lose some of their importance.

This does not mean that we do not know what will make good, long-lived insulation, but that this knowledge is at present confined largely to the use of materials the expense of which prevents their universal commercial acceptance.

As concerns electric tests these can be subdivided into breakdown dielectric tests, and insulation resistance and voltage tests, the former being made on samples and the latter on complete product.

From 3000 to 28,000 volts are used on breakdown tests, according to thickness of insulation, and from 1500 to 8000 on voltage tests, which would seem to be high enough for all practical work on low-voltage wire. These voltage, breakdown, and insulation tests are made after immersing samples or coils of wire in water from 12 to 72 hours, or more, one side of the circuit being placed on the copper and the other grounded in the water in the tank.

The insulation resistance is usually taken after the voltage test, and should indicate from 100 to 1000 megohms per mile of wire, or more, according to the size of the wire and views of different engineers.

Physical tests are made by introducing samples of compound into the jaws of testing machines, and stretching same to determine elasticity and strength.

The chemical tests are many and complex; the amounts of resinous matter, saponifiable matter, sulphur and mineral matter are determined separately by dissolving these ingredients in solutions which affect each one alone, and, after obtaining quantities of same through usual process of filtering, drying, &c., the amount of pure rubber is arrived at, through the process of elimination. —*Electro-craft.*

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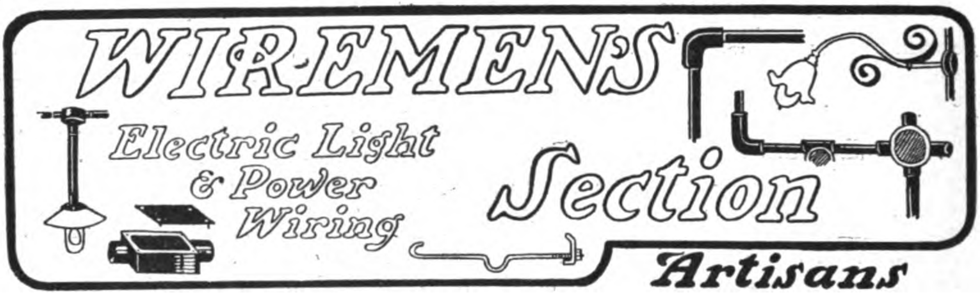

Wiremen and Artisans should refer to the World's Electrical Literature Section for classified list of articles on subjects of importance to themselves.

*Breakdowns of Electrical Machinery.**

LLEWELLYN FOSTER.

To deal with the various parts of a machine that have been known to fail and cause breakdown the author divides them into the following four divisions:—(1) Stationary parts carrying current; (2) stationary parts not carrying current; (3) moving parts carrying current; (4) moving parts not carrying current.

Division No. 1 includes the magnet coils, the brush gear complete, and the terminals. Division No. 2 includes the bedplate or frame generally, the bearings and brasses, and the pole pieces and pole shoes. Division No. 3 includes the armature windings, the commutator segments and lugs, and the binders, whether of wire, cord or insulating strip. Division No. 4 includes the shaft, the spider and core, the bush carrying the commutator, the end ring and "between segment" insulation of the commutator, the winding drums, the lubricating rings, and the pulley, coupling or pinion.

Some breakdowns are purely *accidental*, others are *inevitable*, depending upon the ageing and wearing out of the insulating materials in common use. The majority of failures, and these are the subject of the paper, are *preventable*, being usually due to faulty design, bad workmanship, neglect, inattention, and deterioration of insulation, which is very generally traceable to the want of ordinary and reasonable care.

Referring in rotation to the various parts of continuous-current machines mentioned above:

Magnet Coils.

Many failures have been occasioned by the expansion and contraction that takes place; by the relative movement of the formed winding on the pole piece; by lack of sufficient insulation between the shunt and series windings; by the breaking off of the leading-in wire; by the loosening and breaking away of connections between coil and coil, and by the collection of oil and conducting dust resulting in a breakdown of insulation between the conducting parts and the frame—all these are, in the author's opinion, *preventable*, and call for greater care on the part of both makers and users. On many machines, but more particularly on motors, it is impossible to obtain, with the armature in position, a clear view of, or to get at, the connections between coil and coil, and it is a very difficult matter to clear away the dust, &c., that collects on the sides of the coils furthest away from the commutator.

The question of efficient ventilation is naturally one that largely affects the life of a magnet coil, so many coils burn out from short-circuiting of the inner layers of the conductor due solely to deterioration from heating; unfortunately, when one coil fails in this way it usually results in damage to any other coils in series with it.

Undoubtedly many failures of insulation have resulted from the inductive effect of abruptly opening the shunt circuit, due more often than not to the faulty arrangement of the starting switch and its connections.

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* Abstract of Paper read before the Manchester Section of the Institution of Electrical Engineers, March 5, 1907.

The Brush Gear.

Where carbon brushes are used, the hinge type of holder or the box type is practically universal. The former, if a suitable stop is not fitted, is responsible for several failures, owing to the metal part of the holder coming in contact with the commutator, should a carbon brush either wear away or fall out, and the latter has also occasioned trouble owing to the brushes not moving freely, thus failing to maintain proper working contact with the commutator. In either case sparking, overheating, and flashing over inevitably result. The breakdown of insulation between the brush spindle and the frame, or between the spindle and the rocker bar, is common, and is more often than not due to neglect in keeping such parts clean. On some types of machines this is by no means an easy matter, and is a point that deserves more attention than is usually given to it. There is a tendency, too, to cut down the insulation where it is really required to be particularly substantial and effective. Again, the material used for the insulating bushes and washers should be proof against deterioration from heat, grease and oil; and the leakage path should be made as long as possible.

Brush leads should be securely fixed out of harm's way; often they come in contact with the armature, cross each other under the commutator, or are found to be lying at the bottom of the frame saturated with oil and covered with copper and carbon dust.

The Terminals.

Here again the insulating bushes and washers require to be substantial, and on many machines the position of the terminals might with advantage be altered to make them reasonably accessible for inspection and cleaning. Otherwise they are neglected, and failures occur. Care is also required in the design of terminals to prevent the slacking back and loosening of the set screws—this more especially applies to shunt terminals and connections. Many a motor armature has been wrecked owing to the excessive speed attained in consequence of the weakened field resulting from a shunt wire coming away from its terminal or connector.

The Bedplate or Frame.

Generally speaking, there have been very few failures on these parts due to preventable causes. It would considerably diminish the number of failures on the back ends of armatures if suitable inspection holes for cleaning and other purposes were always provided in the driving end cover plates.

The Bearings and Brasses.

Very many serious breakdowns are attributable to neglect of these parts, and in some instances to bad design. The set-screw intended to hold the brass in position has either broken off or worked loose, allowing the brass to turn over, interrupting the lubrication and causing overheating of the bearing.

Needless to say, if brasses wear down sufficiently to allow the binders, the conductors, or the slotted core to touch the pole faces, considerable damage will quickly be done.

Breakdowns are directly traceable to the oil throwing that seems to be incurable in many types of machines; this is another matter worth the careful consideration of makers in general; very few machines are entirely free from this trouble, particularly if the brasses have worn very slightly. It is really much more serious in its effects than most people imagine.

In all machines proper provision should be made not only for indicating the height of the oil in the wells, but also for emptying and cleaning these out as occasion requires. For the latter purpose a good-size plug screwed with a fine thread is preferable to a cock or a tap which may inadvertently be knocked open or be allowed to leak.

The Pole Pieces and Pole Shoes.

Several breakdowns on armatures have been occasioned by the working loose of the bolts or set screws intended to hold these in position, and some better method than the one generally adopted is required.

The Armature Winding.

The failures that occur in the winding are many and varied; they are mostly due to the deterioration of the insulating material on the winding, which is subjected to movements resulting from expansion and contraction, from centrifugal action, and from internal heating due to lack of efficient ventilation. The failure of one or more of the armature end connections, with the consequent burning away of the corresponding insulating segment on the commutator, is of very frequent occurrence. It may be due to a variety of causes, and is a matter that merits very special attention. Vibration on an armature due to imperfect balance is also a frequent cause of failure. Undoubtedly, bad workmanship accounts for a fair proportion of the failures, and I think that a completed armature should be subjected to a much more severe test to ascertain the insulation between coil and coil than the makers usually appear to apply.

Former-wound armatures are reputed to be easily repaired, and this is one of the many advantages that is claimed for them; it is the author's experience, however, that it is very often a matter of impossibility to renew one or two burnt-out coils on a former-wound armature which has been thoroughly impregnated with varnish or other insulating medium. The latter is so binding on the formed windings in the slots that the insulation is damaged on those coils that of necessity have to be lifted to effect the repair, and a re-wind is rendered necessary. The result is that what ought to be a comparatively simple and inexpensive repair becomes a lengthy and expensive one. Even if the damage done to such windings, when lifting them, is not apparent at the time of the repair, it quickly develops into a fault and results in subsequent breakdown.

The Commutator Segments and Lugs.

The fracture of the lug at its root is not uncommon and is probably the result of some slight movement due to expansion and contraction, or to the bending of the shaft.

Owing to the same causes the longitudinal bolts intended to clamp a commutator together have failed; in some cases the clamping nut has worked loose due to the lack of a suitable set screw, and the segments have risen or have been thrown out by centrifugal force.

The soldered connections are a frequent source of failure—attributable usually to bad workmanship.

Solid commutators, *i.e.*, those without spokes, are in many cases preferable, since they go far to eliminate the failures due to copper and carbon dust being drawn into the end winding and the back of the commutator. With open spokes there is always a tendency for conducting dust to lodge between them, setting up arcing and breaking down the insulation at that point, and in some cases burning out a coil.

The Binders.

These fail at times in a most unaccountable manner, possibly due even on small armatures to expansion and contraction; more generally, of course, their failure is the result of neglect in keeping a sufficient clearance between them and the pole-faces.

The wedge-shaped insulating strips, now very frequently used for retaining the windings in position, may reasonably come under this heading, and cases are not wanting in which one or more of these have come out, resulting in damage to the winding. The author thinks it advisable to supplement these strips by binders.

The above remarks refer to binders formed of metal, but on many armatures whip-cord binders are used over the commutator end connections and sometimes over the commutator end rings. Their use is not to be encouraged, as it is almost impossible to prevent conducting dust lodging between the turns, even if well varnished, and a failure is usually only a matter of time.

In addition these cord binders show a great tendency to work loose, however well they may have been put on originally.

The Shaft.

It is surprising how little care is taken to avoid abrupt changes of section, sharp corners, and screw threads. Many a shaft has failed for the want of a reasonable fillet where changes in diameter occur. Faultily cut key ways, and Vees cut in the shaft, intended to act as oil-throwers, have frequently caused fractures. More care is needed to ensure the proper fitting of the key or keys in the spider or core. On crane and other reversible motor armatures this is absolutely essential or trouble will very soon ensue from the racking to which they are subjected. Shafts are nowadays made stiffer than they used to be (this is a step in the right direction), as the slightest bending of a shaft is certain to cause trouble with the commutator spokes or the armature end connections.

There appears to be a general tendency to discard spiders, and to key the core plates directly on to the shaft. No doubt this cheapens the manufacture, but it is open to the grave objection that it is practically impossible to renew the shaft (in case of wear or fracture) without stripping off the windings.

The Spider and Core.

Here, again, everything depends upon the accurate fitting of the driving keys—the slightest relative movement invariably causes a failure on the windings. That the core slots should be quite true and smooth throughout their length goes without saying, but many a breakdown has been caused by insufficient slot insulation, more particularly at either end of the core, where often enough it is not carried far enough out. It is a mistake to rely solely upon the tapeing of former-wound armature coils and to use no trough insulation in the slots. This practice has led to frequent failures.

The Bush carrying the Commutator.

It is often found that the method employed for driving this is very inadequate, and relative movement between the bush and the shaft quickly develops. It is preferable, and this practice is largely adopted now, to keep the bush quite clear of the shaft altogether, attaching it in some suitable way to the spider, end drum, or core plate. The commutator as a whole should, of course, be removable without interfering in any way with the armature winding except to disconnect the soldered joints.

The End Ring and "Between Segment" Insulation.

Much has been said and written regarding the relative merits of "natural" and "built-up" mica. The latter can be made quite satisfactory, but it is an undoubted fact that a very large majority of the failures of insulation on commutators is directly traceable to mica which has been improperly "built up." Exactly what happens it is hard to say, but in many pieces of damaged "built up" mica that the author has examined the medium used for sticking the flakes together has apparently worked its way out, or has been destroyed by oil, and carbon or copper dust has worked its way in until a short circuit has taken place.

As a general rule, it is necessary that "built-up" mica should be used for the end rings, owing to their peculiar shape. These rings, particularly on motors connected to a three-wire system with the middle wire and the frames earthed, fail very frequently—the outside ring especially, as it is difficult to keep its narrow edge always clean and free from conducting dust, grease, and oil. There is room for a new insulating material which would be impervious to oil and dust and be unaffected by heat—would always present a hard, smooth surface, and would wear down equally with the copper segments. It is no good shutting one's eyes to the fact that very numerous failures of commutator insulation have occurred, and continue to occur, with undiminished frequency. If the breakdown were only confined to the commutator it would be serious enough, but as often as not it is accompanied by a partial burn out of the armature.

The Winding Drums.

There is not much to say about these except to notice a tendency to cut down the necessary insulation particularly at and over the edges. There would be fewer armature failures if the edges were properly rounded off, and suitable insulation was carried well over.

The Lubricating Rings.

The failures on these are almost entirely due to neglect, but on one or two occasions rings appear to have worn the shaft away very considerably. The author is unable to account for this peculiar action. There is a tendency on the part of some makers to use very light rings, and this has led to some damage to bearings, owing to the quantity of oil raised being insufficient for effective lubrication.

Pulley, Coupling, or Pinion.

With regard to pulleys and pinions, there is not much fear of failure if they are securely fixed to the shaft; but in connection with couplings, more particularly the half couplings used on reversible motors for elevators, electric cranes, &c., many fractured armature conductors have been caused by the coupling key, and in some cases the bolts, having become slack—in some instances the tendency to work loose is aggravated by the fact that the brake blocks act on the rim of the coupling.

Miscellaneous Failures.

Vibration, however set up, is a frequent cause of failure on armatures and commutator spokes. It tends to crystallise the copper conductor, and results in constant trouble on the end connections. Excessive friction between brushes and the commutator has, on occasions, carried the former out of their neutral and into a sparking position, and severe flashing over has taken place.

A little end play on armature shafts is advisable, but oftentimes it has been allowed to become excessive, and the commutator spokes have fouled the brush spindles, or the brush holders, or the back end of the armature has touched the frame, with disastrous results.

The unsatisfactory conditions under which some motors are called upon to work of necessity render them peculiarly liable to breakdown, and their life is very considerably shortened. Such are coal-cutter motors, which have to work in hot and dirty situations, and are subjected to considerable variations of load, and careless attention.

The armatures of hoisting motors on overhead or jib cranes are liable to damage, owing to the excessive speed that is sometimes attained when lowering a load. This is a matter, however, that is now receiving careful attention at the makers' hands. On dynamos with smooth-core armatures failures of the insulated driver bars have been frequent, more often perhaps when such armatures are direct-coupled to a two-crank engine, where the periodic changes in the angular velocity of the shaft appear to cause some motion on the armature bars. This motion continued during many millions of revolutions eventually damages the insulating covering and results in breakdown. Oil has a tendency to find its way along shafts, into the interiors of commutators or to their insulated parts and the end windings where, mixing with carbon and other conducting dust, it is a common cause of failure.

Several cases of failure of the magnet coils fixed on the lower sets of poles, particularly on protected or enclosed-type motors, have resulted from the winding being saturated with oil that had run down from the bearings and accumulated in the bottom of the frame. This would have been prevented, and attention would have been called to the oil leakage if a suitable drain had been provided. All protected and enclosed machines should have provision made for draining the lower parts of their frames. On multipolar machines, failures have resulted from unequal clearance between the armature and the pole faces, as apart from the severe strain that is put upon the shaft owing to unbalanced magnetic pull, "bucking" or surging is set up in the windings.

Conclusion—Some Statistics.

The failures referred to have taken place on machines of every size, type, and age, and are by no means confined to old-fashioned machines working under unsatisfactory conditions, nor to machines that have been at work for a number of years. It may be of interest to note that from figures taken over the last few years of an ever-increasing number of machines, it is found that one machine in every ten breaks down from one cause or another—the average for motors being about one in every nine, and for dynamos one in every thirteen. Needless to say, a large number of the failures are minor ones, but all the same, each constitutes a breakdown in the sense that some repair is needed before the machine can be used again.

Taken over the same period, it is found that for every 100 breakdowns the percentages in which the various parts apparently gave way are as follows:—

	Per cent.
Armatures—electrical parts only...	= 58
Magnet coils	= 11
Commutators and brush gear ...	= 18
Miscellaneous—including mechanical parts of armature, binders, bearings and brasses, &c., terminals, &c.	= 13

and the causes may be roughly classified as follows:—

	Per cent.
Accident	12
Dirt and neglect	18
Age and deterioration ...	22
Bad design and workmanship	18
Overloading	5
Unascertained	25

The "unascertained" form the largest class, as it was unfortunately impossible in a large number of the breakdowns to say for certain what the cause really was.

Taking motors only, the author is very decidedly of opinion that unsatisfactory starting switches and controllers, and the careless way in which (if otherwise satisfactory) these are used, is responsible for a large proportion of the failures which form part of this "unascertained" class.

In conclusion, the author expressed thanks to Mr. Michael Longridge for allowing him to use some of the data relating to electrical breakdowns that during the past few years have formed part of his interesting annual report.

MEDICAL ELECTRICITY.

Dr. Schnée's Four-Cell Bath.

ARTHUR ROBERTS, M.D.

The rapid strides made in the employment of electricity during the last twenty years has extended to its use in the treatment of disease, and amongst the most recent improvements has been the introduction of Dr. Schnée's four-cell bath.

The illustrations, Figs. 1 and 2, show the most recent form of the four-cell bath as made by the Sanitas Electrical Co., who are specialists in electro-medical apparatus. It will be noticed that there are four cells or compartments made of porcelain with a central chair, and so arranged that the patient can have the various limbs inserted in water in the separate compartments.

The other diagram shows a trolley on which is a motor and switchboard. This is so arranged that any current may be applied to either the arm or the legs, or to only one limb if so desired.

By this arrangement any of the following currents may be employed in the treatment of disease.

1. The sinusoidal alternating current.
2. The galvanic current.
3. The galvanic faradic current.
4. The faradic current.
5. The pulsating continuous current.

These currents can not only be used with the four-cell bath, but also with ordinary electrodes in the same way as electricity has been given to patients in the past.

The following extract gives a complete account of the advantages of the four-cell bath.

The object of electrisation is to pass the electric current through the human body, so as to subject its organs to the action of the current. Usually, two electrodes are placed at different points on the body, and the electric current between them passes mostly along the surface, although some of it also penetrates to a certain depth. This system does not permit of uniform electrisation of the whole body, whereby the internal parts may be reached by an effective dose of current. Furthermore, this system has also the disadvantage of making it impossible to apply strong currents painlessly, for the increase of the pressure of the current is also accompanied by an increase in its density at the surface of the electrodes, unless the electrode surface be enlarged. The latter remedy is only practicable within certain limits, as large electrodes, owing to the difference of level of the surface of the body, cannot be arranged with uniformly close contact and uniformly strong pressure all over.

In order to produce an efficient electrisation of the body, attempts have been made to conduct the electric current into a water bath in which the patient places himself. The electrodes, which usually consist of aluminium and are provided with wooden protectors, are placed in the bath tubs filled with water. They impart the current to the water, which transfers it to the body of the patient. But with this system, the object in view, of passing the current internally through the body, is altogether missed. Of the current entering the water in the baths, only a small portion passes into the patient's body, by far the larger portion following a path direct through the water from one electrode to the other. Consequently, a great loss of current ensues which makes it necessary to send current into the water in larger doses to compensate for the waste.

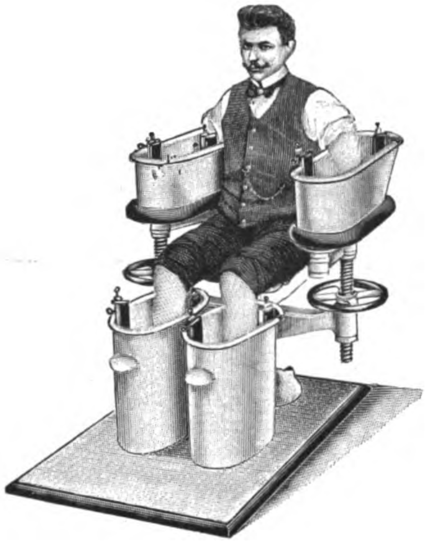

Fig. 1.

This use of the water bath is further attended by another very important disadvantage. The intensity of the current that enters the water bath can be easily ascertained, inasmuch as it answers exactly to the indication of the milliamperemeter, but it is impossible to know how much of that current passes into the bather's body and how much goes through the water only; these are points which can be no more than estimated. This incapability of dosage constitutes one of the chief drawbacks in the electric full water bath. Another disadvantage of this bath is that the electrisation itself can be produced only on the surface, and that very little of the current passes internally through the body. Therefore, in the electric water bath the electrisation amounts more or less to an electrisation of the skin alone, upon which the action of the electric current may be compared to that of bursting bubbles in a bath of carbonic acid.

Hence various arrangements have been devised to conduct the electric current so as to send it as strong as possible actually through the body of the patient; but these attempts have failed to produce satisfactory results. Neither the division of the trough into two compartments by means of a rubber diaphragm (Professor Gaetner's double-cell bath) nor the system consisting in placing one pole outside the water (Prof. Eulenburg's single-pole rod) have entirely remedied the evil. In the first instance, the division of the trough into two compartments is never complete enough for the patient's body to constitute the only conductor between them. Consequently, the electric current always finds sufficient outlets offering less resistance than the human body. In the second instance, the current, it is true, must pass entirely through the body, as it cannot find any other conductor than the hands holding the single-pole rod. In such case, however, only relatively weak currents, which for the section of the trunk are extremely low, can be applied, as currents of even average intensity would cause unbearable pains in the patient's arms and joints of the hands.

As to the hydro effects of the electric water bath, which by some are considered as very beneficial, they have absolutely nothing to do with the case, for they may be produced quite as well by any other non-electric water bath. If, therefore, it is desired to bring forward some better system, it is necessary that such system should do away with the above-mentioned disadvantages

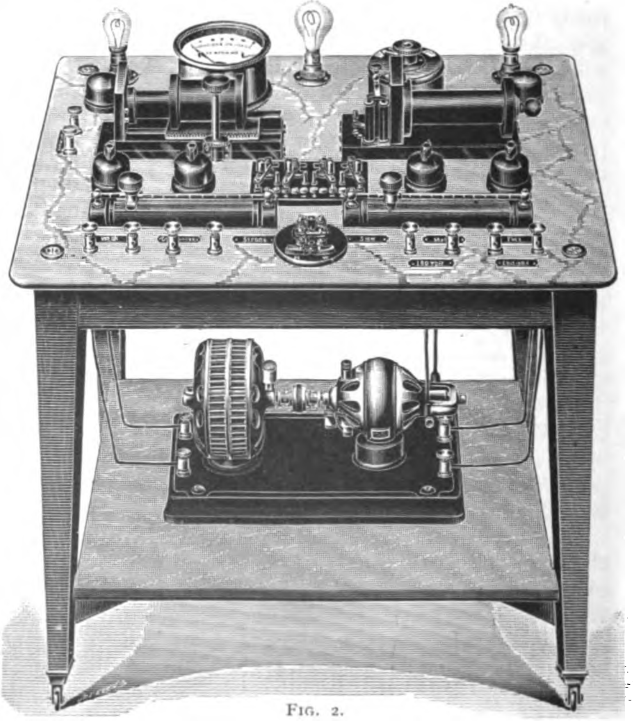

Fig. 2.

of the ordinary electric water bath, which are responsible for the insufficient depth of action of the electrisation, impossibility of dosing, and great loss of current.

An apparatus which meets the requirements in every way and permits a perfect and exact electrisation of the whole body, as well as of the separate parts and organs, is the so-called four-cell bath, as constructed by Dr. Schnée. In this, as the name implies, are four compartments separated from one another, preferably made of porcelain, in each of which an electrode—a couple of carbon plates or carbon rods—is provided. The compartments are filled with water up to a sufficient height to cover the immersed arm up to the lower third of the arm above the elbow, and the leg up to two-thirds, and the electric current from the carbon electrodes in the water of any particular compartment is conveyed from the same to the immersed extremity. In reality, it is not the carbon that forms the electrodes, but the surface of water which immerses the skin of the extremity and from which the current enters the body. This surface is as large as the surface of the extremity immersed in the water and has an area which is many times larger than that of the largest plate electrode that can be used with ordinary electrisation. Consequently, with the four-cell bath, it is possible to apply painlessly currents of great intensity, as the density of currents at the electrodes and on the skin is never great enough to cause the patient to feel any pain or even any burning or discomfort.

Between these large surface electrodes which provide an inlet or outlet for the current at all the extremities, we only have the trunk acting as conducting medium.

The whole current led into the compartments must therefore pass, with full intensity, actually through the patient's body. Its inlet or outlet may be effected at will at one or more extremities, and the means is also provided, according to the different extremities chosen, to alter in various ways the direction of the current Fifty such directions are possible. They enable the operator to subject each organ of the body in preference to any other to the action of the current, and to carry out the treatment, exactly according to the particulars of the diagnosis. The four-cell bath permits thus at the same time a general electrisation or a local electrisation in the most convenient form and with certainty of success.

In the four-cell bath the whole current that is used is made to pass through the body. The intensity of the current that travels through the body may be precisely measured, and the operator has therefore an absolute control over currents of any intensity, and is informed whether the desired degree of intensity is produced. This is an indispensable condition for electrisation and, above all, for galvanic treatment, if any medical treatment of a rational character is to be obtained.

As the electric current in the four-cell bath only enters and leaves the patient's body through the extremities, there is not even any necessity for the user to undress, and all he need do is to make bare the arms and legs. This is a great convenience, both for the doctor and the patient. On the grounds of propriety alone, especially in the case of electrisation of women, the fact that it is unnecessary to undress considerably facilitates and simplifies the treatment, and, in fact, in a number of cases it is an indispensable condition. Furthermore, the necessity of undressing is often found so troublesome and takes up so much time that the patients even prefer to give up the treatment altogether. Moreover, there are a large number of persons who, owing to the nature of their disease, are unable to dress and undress without assistance, and for whom the simplest motions are impossible. This class includes, for instance, the gouty with stiffness of the joints, but especially those suffering from heart disease, in whose case the slightest physical exertion is sufficient to cause difficulty in breathing, oppression, and nervousness.

In the case of those suffering from heart disease and nervous debility, the four-cell bath is again, for another reason, the most convenient apparatus, because no bath tub with water is required. The patient is not obliged to lie down, but may sit erect and comfortably on a bath stool which may be adjusted so as to be exactly adapted to the height of the user. With the four-cell bath, the patient hardly feels that he is being subjected to a therapeutic operation; he feels free and easy and sits safely on the bath stool as comfortably as he would on an ordinary chair. The water bath making it necessary for the patient to occupy a lying position and necessitating the uncomfortable pressure of the water, and the smooth and slippery bath tub which offers no grip when the bather rises, all this causes those suffering from heart disease and nervous debility an unpleasant feeling which frequently leads to difficulty in breathing and to nervousness, so that sometimes the electric full water bath does more harm than good. Owing to these circumstances, the doctor often finds himself compelled to give up altogether the treatment by the electric water bath. The treatment with the four-cell bath is extremely simple.

The following diseases are specially described as receiving marked and curative benefit from the four-cell bath: Diabetes mellitus and the various neuralgiæ and pains associated with it; neurasthenia, paralysis of all kinds, cramp, neuralgia, sciatica, lumbago, rheumatism, gout, heart disease, and, in fact, all diseases which have been cured or benefited by electricity.

Another important class of troubles which have been benefited by the four-cell bath is the after-treatment of accidents.

Prof. Dr. von Noorden, of Frankfort, refers to the results which he obtained with the four-cell bath in the case of several diabetic complications, and mentions among others particularly neuralgia, cramp, general muscular debility, persistent insomnia, pruritus universalis, psoriasis. In the case of non-diabetics he treated cases of muscular rheumatism, neuralgia brachialis, ischias, muscular debility due to neurasthenia, akroparæsthesis, muscular atrophy, arthritis urica chronica, and shrinking of the kidneys.

Dr. Lossen, of Darmstadt, writes in 1904: "A large number of cases of cardial muscular weakness and consecutive dilatation were successfully treated by the application of alternating current in the four-cell bath. The same applies to the cardial muscular weakness of alcoholists, the affections of the heart after muscular over-exercise, cardial muscular weakness after general digestive disorders, and also anæmia due to insufficient cardial exercise, dilatation through excessive nervous excitement, vaso-motor neurosis, chronic ailments after accidents, &c. With regard to the other forms of disorders which seem to demand treatment by the electric four-cell bath, besides neurasthenia and hysteria, there are the greatest variety of the maladies of the peripheric nervous system, and among them particularly neuralgia, paralysis, and cramp."

It is not necessary to add more information as to the value of this treatment; but one important point has to be considered—namely, *Cataphoresis*, which is the introduction of medicines into the system through the unbroken skin. Many will be astonished to learn that medicines may be driven into the system by electricity, but the fact has been proved over and over again by finding the medicine, such as iodine, in the urine.

It is just a hundred years since Reuss demonstrated the electrical transfer of liquids through a porous septum; and in 1817 Parrett proved that medicine could be sent into living tissues. Since then various medical men have observed the same effect, and in 1859 Sir B. Richardson demonstrated that he could produce anæsthesia by narcotics with electricity.

Now it has been proved beyond doubt, and electricity is often used as a means of introducing medicine into the system. Dr. Hedley describes a case of deformed gouty knuckles cured by cataphoresis by the introduction of piperazine and lithium. More recently Dr. Lewis Jones has demonstrated that rodent ulcer has been cured by one application of cataphoresis, and many others have been cured by a few applications. Ozæna and other diseases of the nose have been cured. Lupus has also been reported cured by cataphoresis. The enlarged joints of the fingers in gouty subjects and enlarged knees have also been reported cured.

With the four-cell bath, the conditions for the process of cataphoresis are particularly favourable. The surfaces of the electrodes, the possibility of causing the electric current to enter the body at various points (as many as three at the same time), that is to say, of controlling the extremities positively, the applicability of currents of an absolutely high intensity, and the system of arranging the electrodes in compartments which are separated from one another, all this facilitates the process of cataphoresis.

Without these conditions such cataphoresis could never be carried out to the same extent and with the same precision as is the case with the four-cell bath. Here we find that even when the electric current has been at work only for a short time, quantities of dissolved medicaments with therapeutic properties have passed into the body, as may be ascertained at any time by a test of the urine.

MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

Up-to-Date Fittings.

The London Electrical Fittings Company, Ltd.

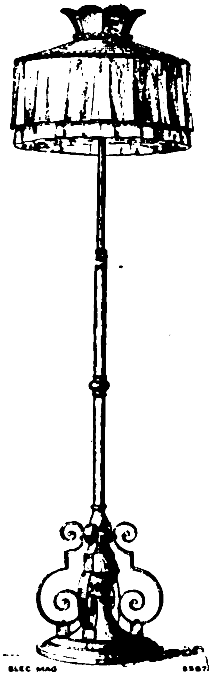

FIG. 1.

We lately had occasion to visit the new showrooms of the London Electrical Fittings Company, Ltd., recently opened at 15, Newman Street, Oxford Street, W. This firm works entirely for the trade, and we have every confidence in recommending those of our readers who are engaged in electric light contracting to send their customers to these showrooms to make their own selections; in all cases they can be certain of every attention and courtesy, and the interests of the contractor are carefully looked after. Books of introduction cards are provided by the firm for this purpose, and can be had on application.

The fittings, which are of an exceptionally high grade of manufacture and finish, are all designed and made at the Company's works in London. This not only ensures prompt delivery, but has the further great advantage that the contractor is enabled to keep in touch with the work while it is in progress of manufacture.

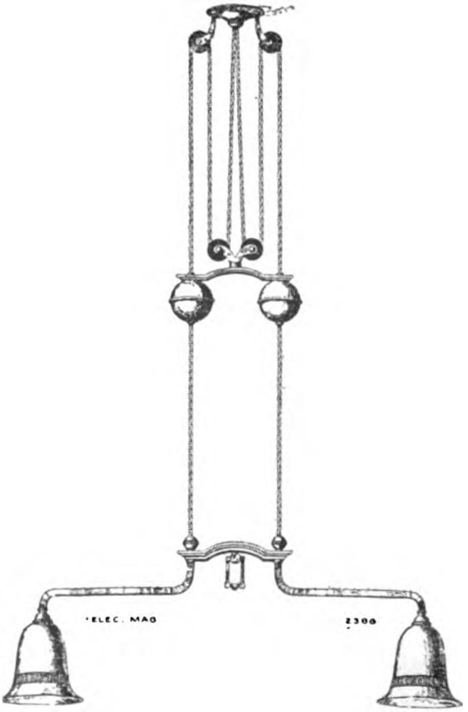

FIG. 2.

A very large selection of fittings is shown in varying styles and over a wide range of prices meeting every requirement, and at the same time this firm is doing a very large business in fittings to special designs. We illustrate one or two of their latest patterns which will give our readers a very fair idea of the work shown. Fig. 2 shows a new type of two-light rise-and-fall pendant with twin weights in place of the usual single weight; the weights form a steadying guide to the wires. In Fig. 1 is illustrated a massive Georgian form of floor standard with heavy cast scrolls, whilst in Fig. 3 we show the Company's latest design of

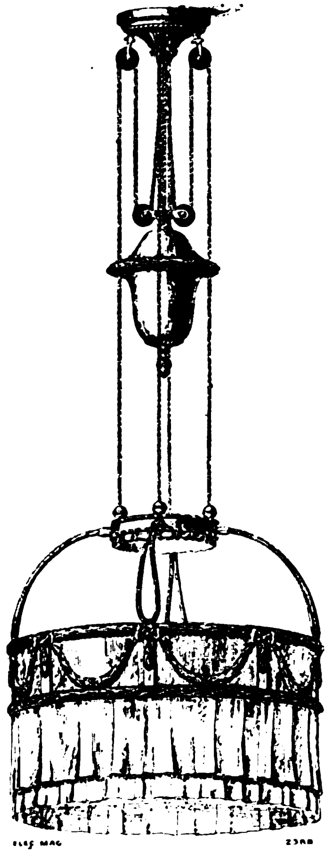

FIG. 3.

dining-room shade light in the Adam style. In addition to the electric light fittings they also display a good selection of electric lamp radiators for heating purposes. Some of these are of the open type adapted for standing in the room, whilst others are built up suitable for the grate. A selection of the "Wandsworth" accessories, including their well-known switches, cut-outs, plugs, fuseboards, &c., can also be inspected.

* * *

SPECIAL:

The Textile Number *of* ***The Electrical Magazine*** *will appear in July.*

Electrical Manufacturers will perceive the ***Great Business Potentialities*** *of this Unique Publication.*

Particulars of ***Specialities*** *for, and* ***Work Done*** *in, the* ***Equipment of Textile Factories*** *should be sent at once to*

The Editor,
THE ELECTRICAL MAGAZINE,
4, Southampton Row, London, W.C.

Electric Transporters and Pulley Blocks.

Kramos, Ltd., Bath.

In these days of "hustling" any appliance which effects a saving in labour and expense is sure to be of interest to all up-to-date engineering firms. Electric pulley blocks and transporters are now recognised as an essential part of any lifting or handling plant, and are rapidly superseding hand cranes and ordinary chain pulley blocks.

Some useful types are manufactured by Messrs. Kramos, Ltd., Bath, whose specialities in this direction cover a wide range of speeds and sizes to suit all practical conditions.

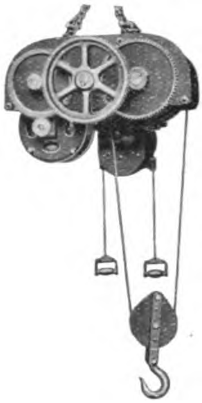

FIG. I. ELECTRIC PULLEY BLOCKS (SUSPENSION TYPE), WITH OR WITHOUT BALL-BEARING TROLLEY.

These time- and labour-saving appliances are divided into five groups as follows:—

1. For suspension from any convenient girder or beam, for which purpose two eye bolts are provided (see Fig. 1).
2. For travelling on a girder, the pulley block being provided with four ball-bearing rollers, and the travelling motion obtained by pushing the load by hand.
3. Similar to No. 2, but for loads too heavy to be pushed by hand, the ball-bearing rollers being operated by sprocket wheel and chain.
4. For travelling by means of electric power with separate controllers and motors for hoisting and travelling (see Fig. 2).
5. For telpherage. A cage is provided on the pulley block in which the operator sits and controls the two motions of lifting and travelling.

In the smaller blocks the motor and the winding drum are compactly arranged between the two side plates, which are securely stayed together, carrying on the outside the gearing, brake, and controller, whereas in the larger sizes the drum and the gearing are inside the plates. The two motors are arranged on one side, and the

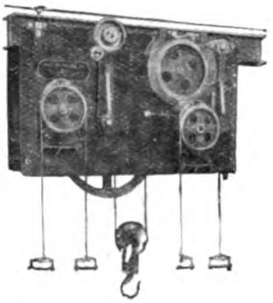

FIG. 2. MONO-RAIL ELECTRIC TRANSPORTER, EQUIPPED FOR ELECTRIC POWER TRAVERSE.

two controllers and brake on the other side of the blocks.

The capacity of the several types ranges from 3cwt. to 4 tons, and the lifting speed from 35ft. per minute to 6ft. per minute, whilst the travelling speeds are between 250ft. per minute and 60ft. per minute.

The motors are series-wound and the lifting speed therefore varies in proportion to the load to be raised. Spur gearing throughout is employed, this being much more efficient than worm gearing. All wheels are of steel with machine-cut teeth.

The controllers are of the reversible crane type and operated by means of two labelled handles suspended by ropes.

A very substantial brake is provided, combined with the controller; this is fitted with cast-iron shoes lined with leather. Magnetic brakes are also fitted when desired. The blocks throughout are of British manufacture, solidity and extreme reliability being the keynotes of these, as with all other manufactures of this firm.

Messrs. Kramos advise that they are at present designing an entirely new form of pulley block which contains some novel features and which will be fully described in a future number. The manufacturers have just published a very complete catalogue dealing with their specialities, and all readers particularly interested in electrically driven auxiliary engineering devices should obtain a copy.

The Triumph Cable Drum Carriage.

John Ruscoe & Co., Ltd., Hyde, Manchester.

THOSE having to do with the handling and laying of electric cables have often felt the need of a cable drum carriage capable of dealing expeditiously and economically with the distribution of large and heavy cables. The cumbersome and unweildy proportions of the usual type of four-wheeled vehicle, built either of wood or iron, have always conduced to defective design and stability. It always set up a large amount of drawing friction, caused by the four small wheels, and was generally very difficult to manipulate in the way of backing up to the drums. The method of loading was on very primitive lines, always entailing the services of two men, both in loading and unloading, and these operations have been mostly performed by means of vertical

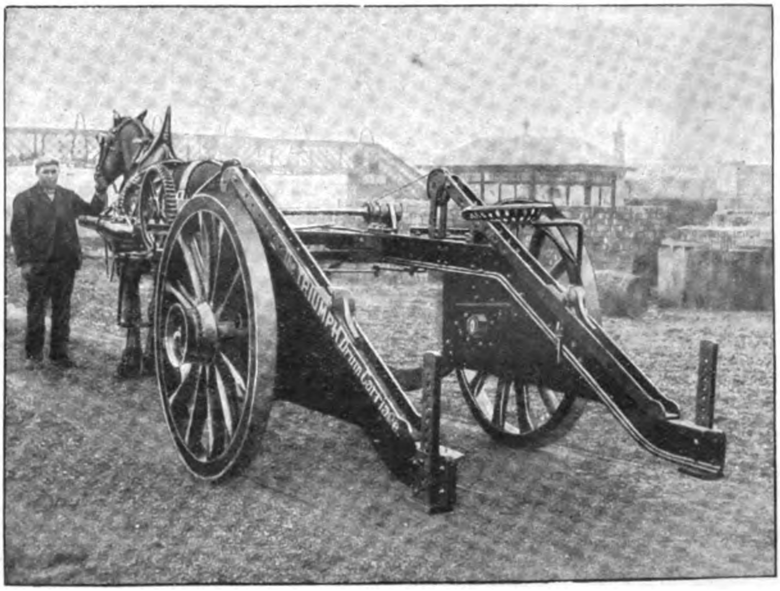

FIG. 1. THE TRIUMPH CABLE DRUM CARRIAGE.

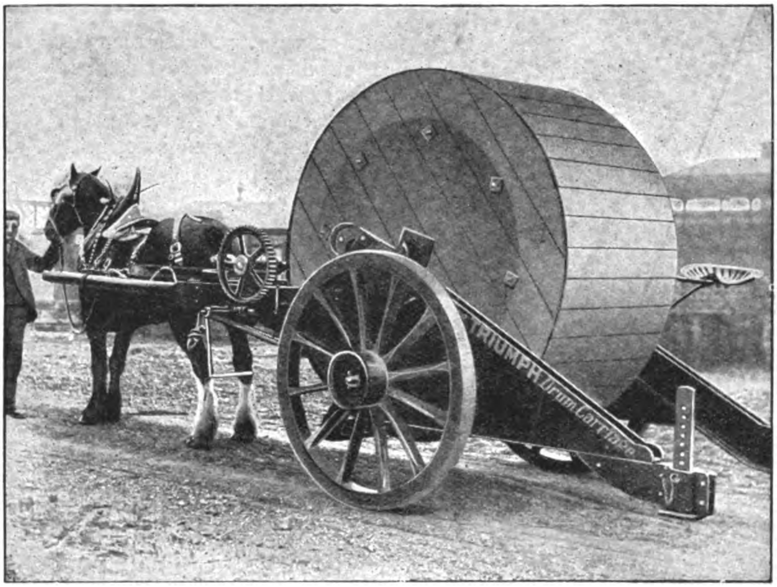

Fig. 2. The Triumph Cable Drum Carriage.

screws working simultaneously on either side of the carriage, these operations being extremely slow. The weight and friction drag of these carriages have always necessitated two horses being employed.

The patent Triumph cable drum carriage has been designed to entirely solve these difficulties, and the work of loading, conveying, and unloading drums up to four tons in weight can now be done with this new appliance and one horse, with one man in attendance.

Drums can be loaded in four minutes and unloaded in rather less time. The diameter of the two wheels, being 56in., gives great ease and speed in travelling It is claimed that the Triumph drum carriage effects a saving of 60 per cent. on the working costs of any other type of carriage.

The two illustrations show clearly the general principle and design of the Triumph carriage. The body is built entirely of steel, the wheels and shafts only being of wood. The carriage is simple in operation, has no loose parts to get lost, and any carter of ordinary intelligence can use it without any assistance. The raising of the drum is effected by means of a powerful worm gear, and an ordinary youth can easily raise a four-ton drum.

An important advantage of this carriage is that, when loaded and hills are to be climbed, the weight can be brought forward as required, and retired when going down hill. The carriage is also fitted with an efficient lever brake, and is perfectly safe and light running. It will accommodate drums up to 7ft. 4in. diameter, by 3ft. 11in. wide.

When loading or unloading operations are going on the steel drop shoes at the rear of the carriage are lowered to the ground and pinned in position, thereby placing the vehicle practically on four feet, so that the horse stands perfectly free. At tests made with a Triumph carriage before a number of Corporation engineers, a four-ton drum was loaded in four minutes and unloaded in three. One horse removed a drum of four and a half tons weight, whilst a drum of three tons was drawn up an incline of one in nine and over very soft and broken ground. These results speak for themselves; the new machine will undoubtedly come into very general use.

◆

MEDICAL ELECTRICITY:

In view of the growing importance of this branch of applied science, *The Electrical Magazine* proposes devoting a complete section to the subject in the next issue, and to publish thereon several articles of great interest and value by experts, to which the attention of leading medical men and the heads of Institutions throughout the country will be directed.

ELECTRICAL APPLICATIONS IN THE TEXTILE INDUSTRIES:

The July issue of *The Electrical Magazine*, dealing with the above, will be a compilation of the greatest possible interest and value to all engaged in the textile trades and electrical manufacturers alike.

Tangible support is being accorded by leading firms and specialists throughout the country, and it is intended to make this issue one of the most important "Specials" ever produced by *The Electrical Magazine*. See particulars in Editorial, page 305.

LITERARY Section.

Including

Reviews of Books, List of Practical Works,
Publishers' Notices, Standard Publications,
WORLD'S ELECTRICAL LITERATURE,
New Catalogues, &c.

Readers will find this Section invaluable. We shall be pleased to furnish further particulars regarding the Books dealt with herein, or to supply information concerning any other books. Communications requiring an answer through the post must be addressed to Literary Editor, ELECTRICAL PUBLISHING CO., LTD., 4, *Southampton Row, London, and accompanied by stamped envelope.*

STUDENTS' MANUAL.

Electrical Engineering in Theory and Practice. BY G. D. ASPINALL PARR, M.SC., M.I.E.E., A.M.I.MECH.E. (LONDON: MACMILLAN & CO., LTD. PRICE 12S. NET.)

In this book an attempt has been made to give a full treatise of the principles underlying electrical engineering as in its present advanced stage. There is no dallying with the history of the subject, and only those early experiments and practices which have a direct bearing upon modern work are introduced. It is essentially a book for the student, and its upwards of 400 pages are brimful of information arranged in excellent sequence and in a style which is sure to be productive of the best results when adopted as a class text-book. There are in all ten chapters devoted respectively to: Magnetism, Static Electricity, Current Electricity, Resistance, Electro-Magnetism, Electro-Static and Electro-Magnetic Induction, Electrical and Magnetic Instruments. Incandescent Lamps, Arc Lamps, and The Production of Electro-Motive Force. Each of these chapters is supplemented by a collection of all questions relating thereto as set by the City and Guilds Institute for the Electro Technology Examinations in the Preliminary, Ordinary, and Honours Grades.

In the preface the author intimates that the theory of generation, transmission, and distribution, and the machinery utilized therefor, will form the subject either of a continuation to the present book or a separate volume. If this promised work is as thorough as the one under notice it will be quite sufficient and the two will form in themselves a complete text-book for the guidance of the student in electrical engineering.

A. C. MACHINES.

The Testing of Alternating-current Machines IN LABORATORIES AND TEST ROOMS. A PRACTICAL WORK FOR STUDENTS AND ENGINEERS. VOL. 1, GENERAL TESTS; TRANSFORMERS; ALTERNATORS. BY CHARLES KINZBRUNNER, A.M.I.E.E. (LONDON: HARPER AND BROTHERS, 45, ALBEMARLE STREET, W. PRICE 4S. 6D. NET.)

As is the rule with Messrs. Harper's technical publications, this book is at first sight pleasing in its clear type and effective and ample illustration. The diagrams in this case are exceptionally profuse and useful. The scope of the book is evident from its title, and it will be found to fully effect its intention as a guide to student and engineer in laboratory and test-room.

The value of this book rests in the fact that it gives in convenient form valuable information which could otherwise only be obtained by reference to many more pretentious works. Its subject is one which becomes ever more prominent in practice. For these reasons it is bound to have a ready sale, and indeed a copy should be obtained by every electrical engineer as a work of reference on the performance of alternating-current machinery.

ELECTRIC WIRING.

Electric Wiring. BY W. C. CLINTON, B.SC. (LOND.). (LONDON: JOHN MURRAY, ALBEMARLE STREET. PRICE 2S.)

This little book indicates on its title-page that it is a "Primer for the Use of Wiremen and Students." The copy to hand is of the fourth edition, which enviable position has been attained after only four years' existence. There is a distinct shortness of books suitable for the electric wiring industry; odd chapters are found here and there in general text-books, which, as a rule, give information on wiring practice which amount to practically nothing, and sometimes less, in that they are out of date and misleading.

Here we have a book which is up to date and depends for its value solely upon wiring and indoor installation work. It is quite reasonable to assert that Mr. Clinton's book is essential to all engaged in the wiring industry, and it will come as a great boon to those who are working for the Wireman's Certificate and the Preliminary Grade of the Technological Examinations.

MOTOR-CAR ENGINEERING.

Self-propelled Vehicles. A PRACTICAL TREATISE ON THE THEORY, CONSTRUCTION, OPERATION, CARE, AND MANAGEMENT OF ALL FORMS OF AUTOMOBILES. BY JAMES E. HOMANS, A.M. (NEW YORK: THEO. AUDEL & COMPANY. PRICE 10s. 6d.)

This is the sixth edition of a work which has proved remarkably popular. The thriving motor-car industry has advanced by such leaps and bounds that there has not yet been time for the appearance of the inevitable rush of text-books thereon; consequently this American book, which handles the subject thoroughly, occupies a unique field, almost without competition. Yet it is remarkably complete, and no pains have been spared to cover the ground of steam, petrol, and electric vehicles in thorough detail. The design of vehicles, engines and equipments, the performance of cars, the handling and maintenance of every type ranging from those of cycle weights up to motor vans and omnibuses, are all fully entered into, and the text is illustrated by an exceptionally useful series of over 500 drawings and diagrams.

A POCKET BOOK.

The Technical Year-Book, 1907. EDITED BY ARTHUR C. KELLY, ASSOC.M.INST.-C.E., AND CHARLES WEEKES. (LONDON: PERCIVAL MARSHALL & CO. PRICE 5s. NET CLOTH, 6s. 6d. NET LEATHER.)

In the words of the preface to this book, "it is not a complete guide or index to the two hundred and fifty odd engineering journals published throughout the world . . . its scope is the choosing of such matter only as will give the general reader and practitioner a clear idea of a year's actual advance along broad lines."

It is an excellent reference work of pocket-book size, and contains a wealth of information all useful and often required, which, because of its being entirely up to date, is invaluable. There are in all fifteen sections: automobiles, boilers and steam generation, cables and power transmission, electricity supply, general electrical, general mechanical, generators and motors, hydraulics, lighting, marine, mining, power, prime movers, traction, and general. In each section the most generally useful data, tables, and curves are given. The book should be noted by all engineers as a great time-saver and worth far more than its small cost.

FOR REFERENCE.

The Technical Index. A SYSTEMATIC RECORD OF CURRENT TECHNICAL LITERATURE,

is the title of a periodical published monthly in Brussels, in which are indexed under subjects and again into sub-divisions of special branches of that subject, all the important articles as they appear in the current technical literature of Europe and America. New books are also included, and in every case a synopsis of the contents of article or book is given. This unique publication has just entered upon its tenth volume. It will be found of particular benefit by those who are engaged in study and research work or as specialists.

GENERAL ENGINEERING.

Machine Design. BY CHARLES H. BENJAMIN. (LONDON: ARCHIBALD CONSTABLE & CO., LTD., PRICE 8s. NET.)

A little book of American origin dealing thoroughly with the principles of machine design. Whilst intended as a guide to students, the information given is based upon the author's practical experience and will be found of considerable value as a work of reference for the designer-draughtsman.

Precision Grinding. BY H. DARBYSHIRE. (LONDON: ARCHIBALD CONSTABLE & CO., LTD., PRICE 6s. NET.)

The working of metals by grinding processes is ever coming into more general use. It is essential that those engaged in engineering manufacture should have full knowledge of the art of grinding, of its possibilities, and the most modern machines and methods of applying it. This book is written to impart instruction in this and should consequently be acquired by the works engineer, especially as it is based upon the author's practical experience and study of his subject.

Practical Coal Mining. In the review of this important treatise included in the last month's number of THE ELECTRICAL MAGAZINE, it should have been stated that the Gresham Publishing Company were the publishers of the work, and not the Electrical Publishing Company, Ltd. The latter are, however, associated with the Gresham Company in the sale of the volumes.

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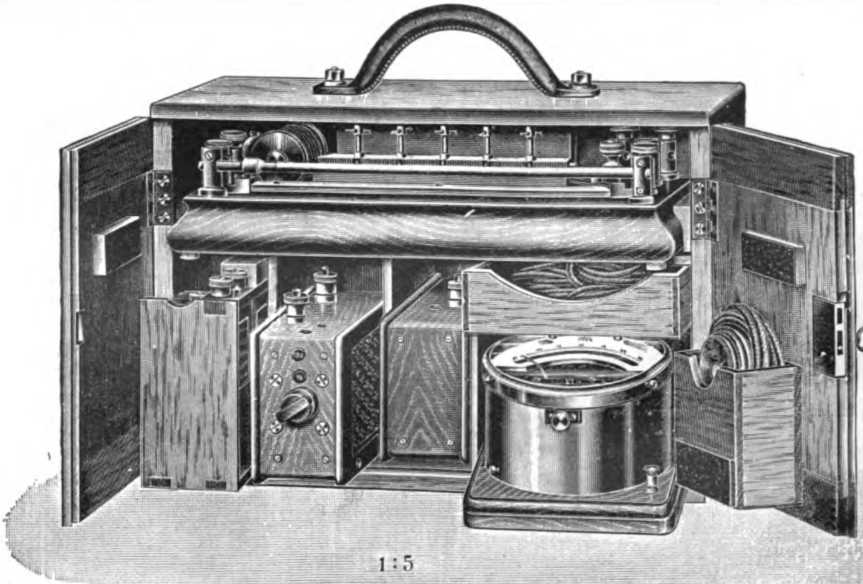

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Power.

Municipal Excavations by Electric Hydraulic Mining System. F. C. Perkins.	*Westn. Electn.,* 27/4/07.
Electric Power in Mills for Printing Fabrics. M. Arbeiter.	*Elek. Zeit.,* 21/3/07.
Tests of High-tension Insulators. W. Weicker.	*Elek. Zeit.,* 28/3/07.
Motors for Machines and Tools. D. Pierce.	*Journ. of Elec. Power & Gas,* 20/4/07.
Storage Battery Plant for Regulation and Carrying Load Peak in Mining Plant.	*Journ. of Elec. Power & Gas,* 27/4/07.
The Design of Centrifugal Pumps. E. N. Percy.	*Journ of Elec. Power & Gas,* 27/4/07.

Traction.

Three-Phase Locomotive with Three Ranges of Speed for the Italian State Railways. B. Valatin.	*Str. Rly. Journal,* 6/4/07.
The Multiple Catenary Suspension for the Blankenese-Ohlsdorf Railway.	*Str. Rly. Journal,* 6/4/07.
Portable Transformer Station. E. Cserhati.	*Elek. Zeit.,* 21/3/07.
Mountain Railways in Switzerland. W. A. Mueller.	*Elek. Zeit.,* 28/3 07.
Railway Signalling: Electric Interlocking. J. D. Taylor.	*Elec. Journal, April/07.*
Transportation Facilities in South America.	*Str. Rly. Journal,* 27/4/07.
The Fort Wayne and Springfield Single-phase Railway.	*Str. Rly. Journal,* 27/4/07.
Specifications for Creosoted Wooden Blocks and Sub-structure.	*Str. Rly. Journal,* 27/4/07.

Central Station Practice.

A New Voltage-regulating Device for Maintaining Synchronism.	*West. Electn.,* 27/4/07.
Electric Distribution Systems. A. H. Ford.	*West. Electn.,* 27/4/07.
Cost of Operating Electric Light Plant. L. B. Spinney.	*West. Electn.,* 27/4/07.
The Design of a 1500-3000kw. Steam-electric Central Light and Power Plant. F. Koester.	*Elec. Rev., N.Y.* 20/4/07.
Protection against Lightning and the Multi-gap Lightning Arrester. D. B. Rushmore and D. Dubois.	*Elec. Rev., N.Y* 20/4/07.
Measurement of Wire and Cable Insulation. T. D. Waring.	*Elec. Wld.,* 20/4/07.
Lubrication in the Power Plant.	*Str. Rly. Journal,* 27/4/07.

Lighting and Heating.

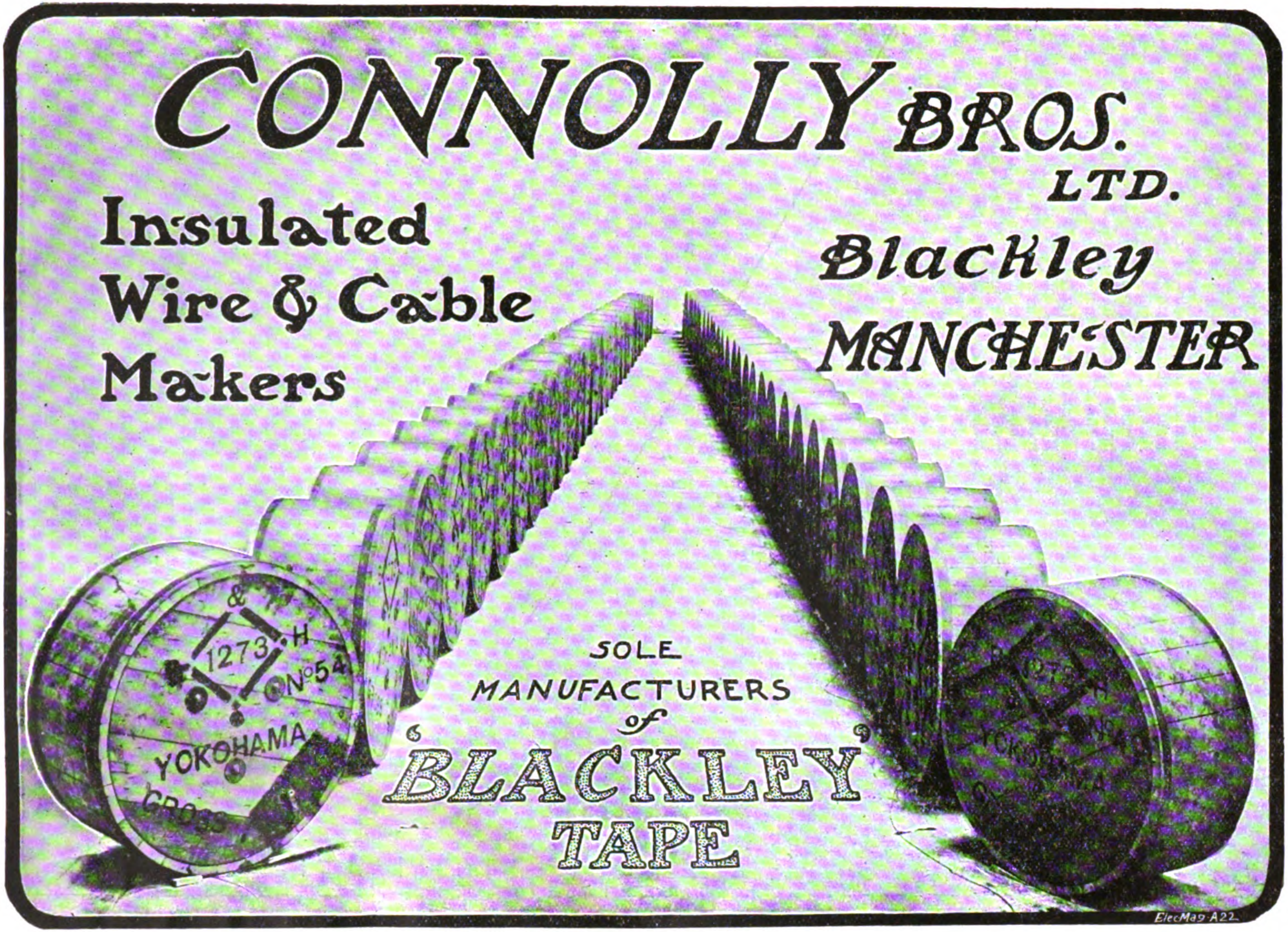
The Properties and Uses of the Arc Produced between Electrodes Consisting of a Mixture of Carbon and Mineral Substances. A. Blondel.	*L'Ecl. Elec.,* 16/3/07.
Selenium in Photometry. P. V. Schrott.	*Elek. Zeit.,* 28/3/07.
Electric Heating and Cooking. A. Lauri.	*Elek. Zeit.,* 21/3/07.
Comparison of Methods of Office Illumination. E. A. Norman.	*Trans. Ill. Eng. Soc., Mar./07.*
Moore Tube Lighting System. H. E. Clifford.	*Trans. Ill. Eng. Soc., Mar./07.*

Telegraphy and Telephony.

Elementary Information Concerning Submarine Cable Telegraphy. W. H. Jones.	*Tel. Age,* 1/4/07.
A New Duplex Method with Battery at One Terminal Only. W. H. Jones	*Tel. Age,* 16/4/07.
The Practical Application of Hertzian Waves. F. H. Austin.	*Tel. Age,* 16/4/07.
The Testing Appliances and Arrangements Required by the Wire Chief of a Modern Exchange. H. P. Clansen.	*Teleph., April/07.*
The Telephone in Hawaii. G. C. Cobden.	*Teleph., April/o*
Use of Curves in Telephony. E. Brofos.	*Teleph., April/07.*
Improvements in Wave Meters and Transformers for Radio-Telegraphy.	*West. Electn.,* 27/4/07.
Improvement in Quadruplex Telegraphy.	*Elec. Wld.,* 20/4/07.
Directed Wireless Telegraphy. K. Uller.	*Phys. Zeit.,* 1/4/07.
Telautography.	*Phys. Zeit.,* 1/4/07.

Design and Manufacturing.

Continuous-current Armature Winding Diagrams (II.). H. M. Hobart.	*Elek. Rev., N.Y ,* 6/4/07.
Transition Resistance of Carbon Brushes as Function of Temperature. E. Arnold and E. Pfiffner.	*Elek. Zeit.,* 21/3/07.
Asbestos Wood. C. L. Norton.	*Elec. Wld ,* 27/4/07.
High-voltage Alternators. W. L. Waters.	*Elec. Wld.,* 27/4/07.
Transformer Indicator Diagrams. T. R. Lyle.	*Phil. Mag., April/07.*
Inter-pole Motors. K. W. Wagner.	*Elek. Zeit.,* 28/3/07.
Circulating Currents in Three-phase Generators. A. G. Grier.	*Elec. Journal, April/07.*
Effect of Armature Reaction in Synchronous Motors and Rotary Converters. B. T. McCormick.	*Elec. Rev., N.Y ,* 27/4/07.



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New Catalogues.

Collins' Testing Brake. — JOHNSON & PHILLIPS, LTD.—An illustrated price-list has now been published describing this convenient form of dynamometer, of which a description appeared in our literary columns in August last.

Polyphase Motors.—MARPLES, LEACH & CO. have issued a new polyphase motor list No. 102A, which is exceptionally complete, covering a full line of two- and three-phase motors ranging from $\frac{1}{8}$h.p. at 1400r.p.m. to 300h.p. at 365r.p.m. The short-circuited rotors of these are made under a patent principle inasmuch as the electrical circuit in the rotor has no joints, the windings being cut from the solid metal, and slipped into place. The motors having wound rotors are provided with a brush-lifting and short-circuiting device. By means of this device the brushes on the slip-rings can be raised after the motor has been started, the rings being short-circuited by the same operation. Wear and tear of the slip-rings, brush-gear, and brushes is eliminated, and the efficiency of the motor improved. Motors equipped with this device thus combine the advantages of the slip-ring motor at starting with those of the short-circuited motor while running. The operation of short-circuiting the slip-rings and lifting the brushes is performed in one motion by means of a lever arranged in such a way that no mistake of any kind can possibly occur.

Readers will find this price-list an extremely useful one, inasmuch as many particulars other than the price of a large range of motors are included.

Rheostatic Controllers and Resistances. —THE BRITISH THOMSON-HOUSTON COMPANY, LTD.—Pamphlet No. 202 describes and illustrates controllers of the drum type and frame resistances for use in conjunction therewith.

Single-phase Induction Motors.—THE BRITISH THOMSON-HOUSTON COMPANY, LTD.—Pamphlet No. 201 is devoted to a detailed description, with illustrations, of a line of single-phase induction motors, giving dimensions, ratings, speeds, weight, &c. Particulars are also given of the starting rheostats supplied for use with these machines.

Electric Bell Prices.—BAXENDALE & CO., Manchester.—This firm advises us that owing to the present high price of raw materials they are compelled to advance all the prices contained in their electric bell list of last December by 5 per cent.

Hot Wire Instruments.—JOHNSON & PHILLIPS, LTD.—Price-list HW gives full particulars and prices of a complete series of hot-wire ammeters and voltmeters as intended for switchboard and portable services. These instruments are of the round type; they are also arranged for edgewise reading and in square cases for demonstration purposes. The portable forms include ammeters and voltmeters mounted in separate boxes or an ammeter and a voltmeter of square type mounted together in one case.

D.C. Generators.—MATHER & PLATT, LTD., Manchester, have sent us a copy of the fourth edition of their useful publication entitled "Multipolar Dynamos." This gives illustrations and standard specification of this well-known line of machines, and also gives particulars of ratings, dimensions, speeds, and weights.

Switches, Fuses, Water-tight Fittings, &c.—ECKSTEIN, HEAP, & CO., Manchester.—This Company's advance catalogue No. 2 gives illustrations and details of a notable line of ironclad main switches and fuses. Several types are also shown of thorough water-tight and gas-tight construction. Other accessories illustrated are iron-clad house service fuse boxes, distribution boards, "Noark" fuses and contacts, bulkhead fittings, &c.

Portable Electric Tools.—KRAMOS, LTD., Bath.—The latest complete list of electrical machine tools and apparatus as built by this firm covers quite a big range of specialities, including electric drilling machines, electric pulley blocks and transporters, brake magnets, capstan switches, &c. It should be noted that the Kramos tools are entirely of British manufacture, and that a particular claim of the makers is that they are of more solid and durable construction than is usual with these smaller electrical tools and accessories. Some particulars of the Kramos specialities in pulley blocks and conveyors are given in the Manufacturing Progress Section of this issue.

Water-tight Cable Couplings.—SIMMONDS BROS., LTD., London.—A striking post-card exhibiting illustrations and prices of the "Niphan" cable couplings, which are ever being more widely used for temporary outdoor work and for portable electric power equipments. A description of the system was given in the special Colliery Number of THE ELECTRICAL MAGAZINE, March, 1907.

Lifts and Cranes.—R. WAYGOOD & CO., LTD., London.—We have received specimens of two or three leaflets from this firm displaying in attractive form some record of their progress. An illustrated price list is also sent of a patent slanting cellar hoist.

Cable Drum Carriage.—JOHN RUSCOE & CO., LTD., Manchester.—A well-illustrated description of the "Triumph" cable drum carriage as manufactured by this firm and of which some details will be found in the Manufacturing Progress Section of this issue.

Conduit Enamel.—Simplex Conduits, Ltd., have sent us a sample of their conduit enamel in the form of a thin piece of tin coated with the enamel. The specimen quite substantiates the makers' claims: by bending the tin backwards and forwards repeatedly there is no sign of the enamel flaking off, but it retains its uniformly hard, smooth surface.

Calcium Carbide Works in Ireland.—There are a number of water powers in Ireland which might be used for the production of power for electro-chemical or electro-thermal preparations. Several of these are being utilised for the production of calcium carbide. In connection with one of these schemes an order has recently been placed by Mr. Frank Broadbent, M.I.E.E., consulting engineer, for a 640h.p. Gilkes turbine coupled to a 430kw. single-phase Mather & Platt alternator. This set forms the second set of this size for the works in question, and the turbine will operate on a 34ft. total fall and develop the power at 300r.p.m Owing to the possibility of getting the furnaces close up to the water power, the alternators are run at low voltage, namely fifty, and are capable of developing up to 10,000 amperes.

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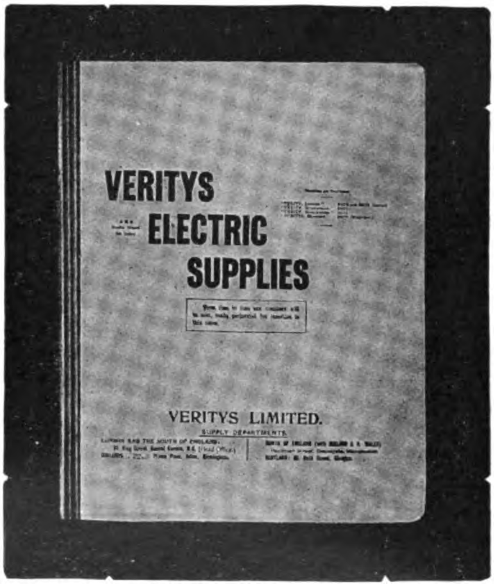

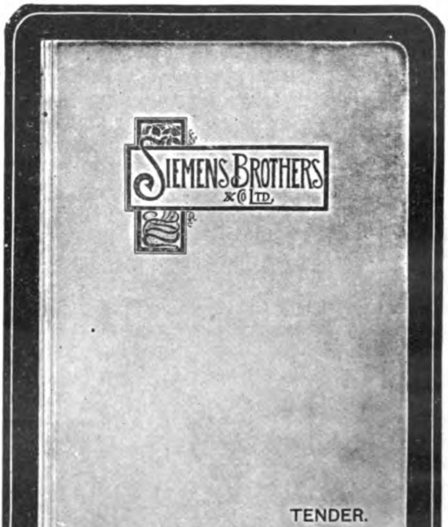

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Trade Notices.

New Addresses.—R. J. NICHOLSON & Co., Manchester. Messrs. R. J. Nicholson's rapidly extending business has necessitated direct representation in London, and they have therefore arranged for offices at 46, King William Street, E.C. Messrs. Umney & Beckett, who have charge of this end of the business, will cover not only the London district proper, but also the counties of Essex, Hertfordshire, Middlesex, Kent, Surrey, Berkshire, and Hampshire. It will be remembered that Messrs. Nicholson make a speciality of direct-coupled petrol engines and dynamos for electric lighting and other purposes, and those contractors who are interested in country-house installation should communicate with this firm. The low prices at which the sets are offered will doubtless in many cases induce those living in the country to adopt electric light in preference to other forms of illuminant. A handsome catalogue, "Light in the Country," is available on application, and one of the sets can be seen running at the showrooms, Macdonald's Lane, Corporation Street, Manchester. The head office telephone number is 5432 Central, and that of the London office is 9876 Central.

W. E. BURNAND & Co., Sheffield, notify that they have removed to new premises, their address now being Chippinghouse Works, Lowfields, Sheffield. The new works are well equipped with modern plant and specially designed tools, and are easily capable of dealing with treble the output possible in their former premises, where they have, for some time, been badly cramped for room, having outgrown the space available.

THE UNION ELECTRIC COMPANY, LTD, London, advise us that owing to the increase of their business in the northern districts, the Newcastle office has been moved to No. 50, Grainger Street, Newcastle-on-Tyne.

MOUNTAIN & GIBSON, LTD., electrical tramway and railway engineers, Elton Fold Works, Bury, Lancashire, have removed their commodious premises to Albert Buildings, 49, Queen Victoria Street, London, E.C. (the corner building at the junction of Queen Victoria Street and Cannon Street, London), telephone No. 2023 London Wall; telegraphic address, "Girders," London. The care of the London sales department is in the hands of Mr. F. W. Newman, director, as heretofore, but owing to the increased volume of business he will be joined by Mr. N. McL. Lawrance, director (from the works), who will attend more particularly to the engineering and technical work.

The business of the firm has very largely developed recently. Some extensive additions have been made to their works, Bury. The plant has been re-organised and added to, and at the present time the works are very fully employed. The orders which they have in hand at the present time include complete tramcars (including the trucks) for Llandudno, Delhi, Coventry, Portstown, and Horndean; and trucks for Nottingham, Leyton, West Ham, Wemyss, Pontypridd, Birkenhead, Stalybridge, Dublin, Bury, Derby, &c., also for Calcutta and Montreal.

In addition the firm have recently secured the contract from the London County Council for the supply of 300 pairs of maximum traction trucks, which are similar to 350 pairs previously supplied. This recent order represents the fifth consecutive order which the London County Council have placed for Mountain and Gibson's improved type of centre-bearing swing-bolster maximum traction trucks, making a total of 650 cars which will be mounted upon this special design. The other orders referred to include a large number of the firm's patent radial truck, which is now being very favourably considered by tramway engineers.

The firm have added many important improvements and modified the designs of their various classes of trucks to meet the requirements of up-to-date tramway practice. Many of these are shown in the pamphlet which they have recently issued describing their manufactures.

Telephone Extension.—THE ARMORDUCT MANUFACTURING COMPANY, LTD., have intimated that owing to many complaints received from customers regarding delays in obtaining telephonic communication with them, they have added a second line. Readers should note that this firm's numbers are as follows: 1394 Holborn; 5739 Holborn.

Large Gas Engines.—THE BRITISH WESTINGHOUSE ELECTRIC AND MANUFACTURING COMPANY, LTD., have recently received an order for their new type six-cylinder vertical tandem gas engine for operating the Hollin's Mill Company's factory at Marple. This will form a duplicate of four now being delivered to the Castner-Kellner Alkali Company, Ltd., at Runcorn.

Condensing Plant.—THE MIRRLEES-WATSON COMPANY, LTD., Glasgow, have just received orders for condensing plant as follows: Surface condensing plant—J. & P. Coats, Ltd., Paisley, three sets duty each 24,000lb. steam per hour; Powell-Duffryn Steam Coal Company, Ltd. (per Messrs. James Howden & Co.), duty 38,000lb. steam per hour; City of Hereford Electricity Power Station, duty 7500lb. steam per hour; Ateliers Thomson Houston's new turbine works, Lille, one set duty 32,000lb. steam per hour; Sunderland Shipbuilding Company, Ltd., auxiliary condensing plant and condenser for Messrs. Gwynnes, Ltd.

Barometric Jet Condensing Plant. W. Beardmore & Co., Ltd. (per Mr. P. J. Mitchell), one set duty 86,000lb. steam per hour; Stewarts & Lloyds, Ltd. (per Mr. P. J. Mitchell), one set duty 86,000lb. steam per hour.

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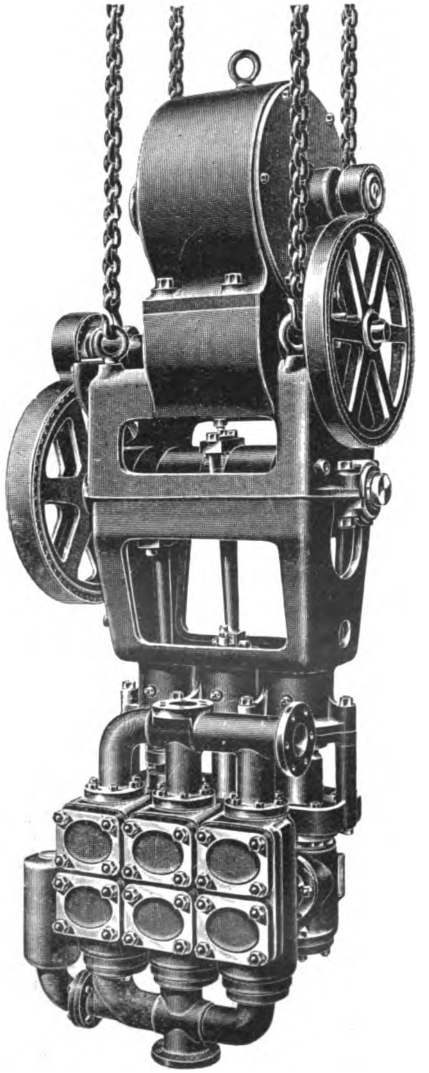

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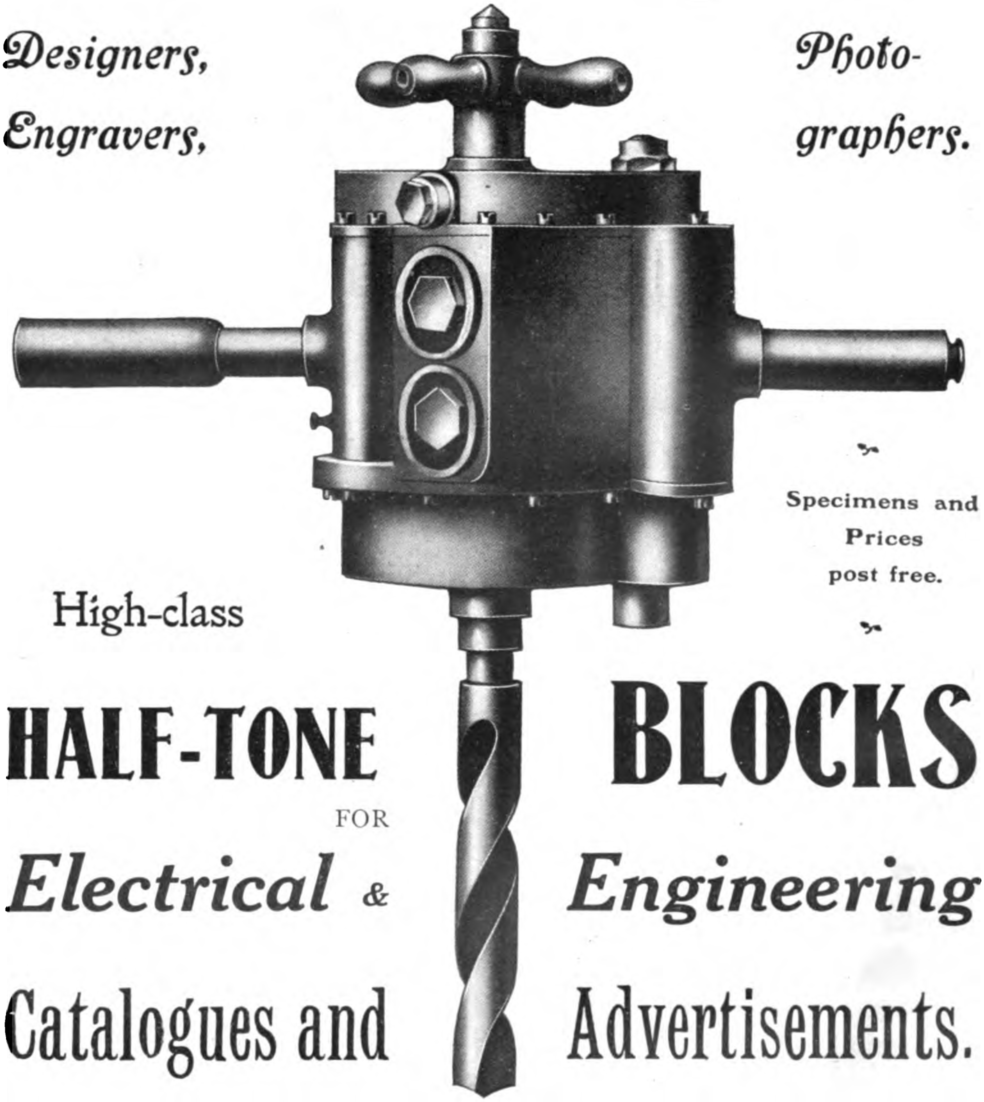

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LITERARY CONTENTS

Of This Issue.

The World's Electric Progress (Editorial) . 361–364
Power and its Application to Industry . 365–366
Traction and Transport 367–370
Central Station Practice 371–372
Lighting and Heating 373–380
Telegraphy and Telephony 381–388
Electro-Chemistry, Electro-Physics, and Electro-Metallurgy 389–392
Students' Section 393–395
Wiremen's Section 396–398
Medical Electricity 399–409
Manufacturing Progress 410–417

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Buyers' Guide — continued from page 2.

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Glaholm and Robson, Ltd., Sunderland.

Index to Advertisers.

For specialities and manufactures of firms below, see preceding Buyers' Guide.

PAGE
A. E. G. Electrical Co. of South Africa, Ltd. . 11
A. E. G. English Manufacturing Co., Ltd. .
Adams Manufacturing Co., Ltd. . . .
Angus, George, & Co., Ltd. . . . .
Armorduct Manufacturing Co., Ltd. . . .
Automatic Standard Screw Co. . . . ii. of cover
Babcock & Wilcox, Ltd. 7
Bennis, Ed., & Co., Ltd. . . . . . .
British Steam Specialties, Ltd. . . . .
British Westinghouse Electric & Mfg. Co., Ltd.
Broadbent, Thos., & Sons, Ltd. . . . .
Campbell Gas Engine Co., Ltd. . . . .
Clarke, Chapman & Co., Ltd. 7
Connolly Brothers, Ltd. 21
Corlett Electrical Engineering Co., Ltd. . .
Craven Bros., Ltd. . . . .
Crompton & Co., Ltd. 13
Crypto Electrical Co. . . . .
Cundall, Sons & Co., Ltd. . . . . .
"Cyclopædia of Applied Electricity" . .
Davis, John, & Son (Derby), Ltd. . . .
Diamond Coal Cutter Co. . . . . .
Diesel Engine Co., Ltd. 10
Dowsing Radiant Heat Co., Ltd. . . . 18
Electric & Ordnance Accessories Co., Ltd. .
Electromotors, Ltd. . . . . . .
Elmes, A., & Co. 22
Engineering and Machinery Exhibition . . 23
Ferranti, Ltd. . . . .
General Electric Co., Ltd. . . . . .
Glaholm & Robson, Ltd. . . . . .
Goodman Manufacturing Co., Ltd. . . .
Green, E., & Son, Ltd. 16
Halden, J., & Co. . . . . . .
Hall, B. J., & Co., Ltd. . . . . .
Hannan & Buchanan . . . . . .
Hardy Patent Pick Co., Ltd. . . . ii of cover

(Continued on page 6.)

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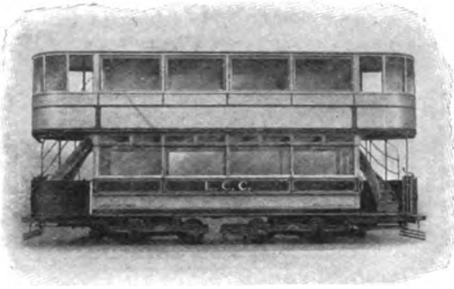

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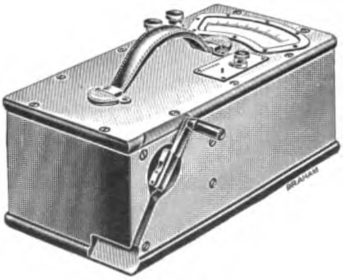

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Index to Advertisers—*continued.*

	PAGE
Hendry, James	iii of cover
High Speed Braiding Machine Co., Ltd.	
Hofler, W.	19 and iii of cover
Holmes, J. H., & Co.	
Hornsby, Richard, & Sons, Ltd.	
Howden, James, & Co.	
Hurd, McKendrick & Co.	
Hyatt Roller Bearing Co.	
India-Rubber, Gutta-Percha, & Tel. Wks. Co., Ltd.	12
Lancaster & Tonge, Ltd.	
London & County Printing Works	29
Macintyre, James, & Co., Ltd.	
Mather & Platt, Ltd.	9
Mavor & Coulson, Ltd.	
McGeoch, Wm., & Co., Ltd.	17
Meldrum Bros, Ltd.	
Mirrlees Watson Co., Ltd.	
"Modern Electric Practice"	
"Modern Engines and Power Generators"	
"Modern Mining Practice"	25
Mountain & Gibson, Ltd.	5
Nalder Bros. & Thompson, Ltd.	5
Neill, W., & Son, Ltd.	
Newton Bros.	
North-Western Electrical Appliance Co.	
Partridge & Cooper, Ltd.	20
Pearn, Frank, & Co., Ltd.	3
Phillips, Charles D.	20
Phœnix Dynamo Manufacturing Co., Ltd.	
Pinchin, Johnson, & Co., Ltd.	
Practical Books	24 and 26
"Practical Coal-Mining"	25
Press Etching Co.	28
Pritchetts & Gold, Ltd.	20
Reason Manufacturing Co., Ltd.	15
Rhodes Electrical Manufacturing Co., Ltd.	
Ross, R. G., & Son	iii of cover
Sandycroft Foundry Co., Ltd.	
Santoni, D., & Co. (1906), Ltd.	
Simmonds Bros., Ltd.	
Simplex Conduits, Ltd.	
Smith (A.) and Stevens.	
"Standard Wiring"	
Stewarts & Lloyds, Ltd.	
Stirk, John, & Sons	
Stolzenberg Patent File Co.	27
Suter, Frank, & Co., Ltd.	14
Switchgear Co., Ltd.	
Temperley Transporter Co.	
Thames Ironworks, Shipbuilding and Engineering Co., Ltd.	
Thom, John G.	iv of cover
Turnbull, Alex., & Co., Ltd.	16
Union Electric Co., Ltd.	17
United States Metallic Packing Co., Ltd.	iv of cover
Waygood, R., & Co., Ltd.	20
Wild, M. B., & Co., Ltd.	
Winn, Charles, & Co.	
"The World of To-day"	
"World's Work"	29

Electrical Applications in the Textile Industries.

The ELECTRICAL MAGAZINE will fittingly inaugurate a new volume next month with an issue which in point of value and importance will be in every way exceptional. The issue in question, as announced last month, will deal specifically and almost wholly with Electric Power in Textile Factories, and it is safe to say that no such collection of informative data, interesting facts and statistics, and special illustrations—the latter representing every possible drive where an electric motor is the power unit—have ever been got together within the pages of a technical journal.

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☛ ***Your special attention is drawn to the interesting details on page 8.***

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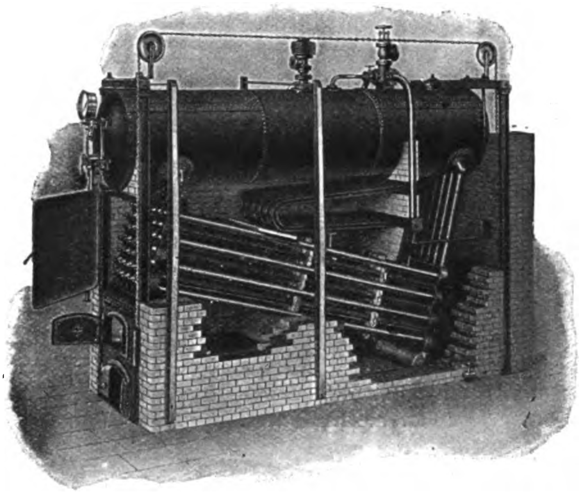

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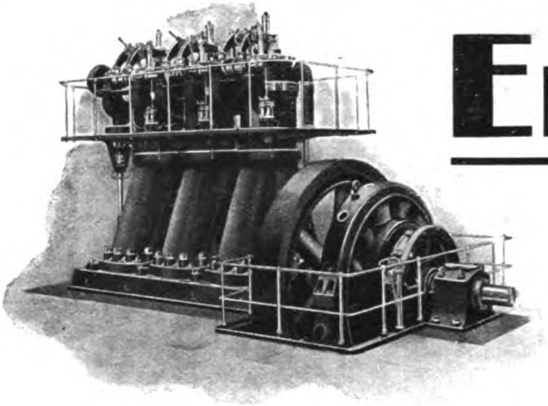

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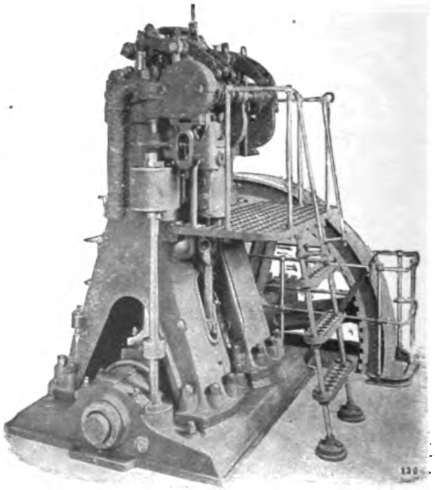

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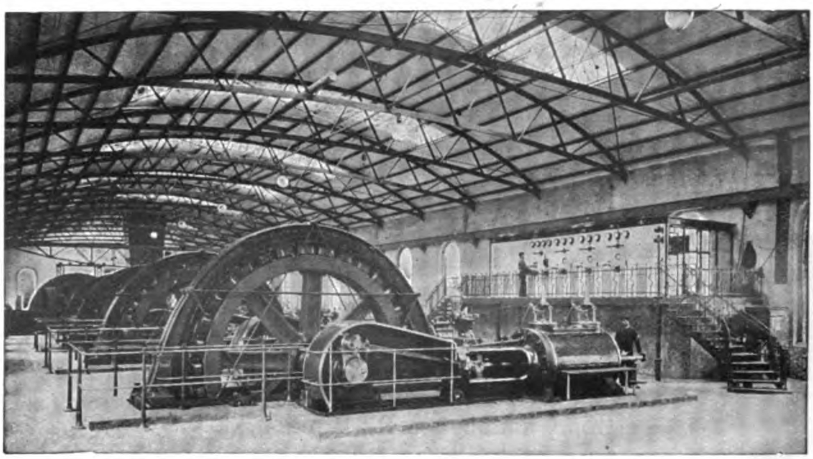

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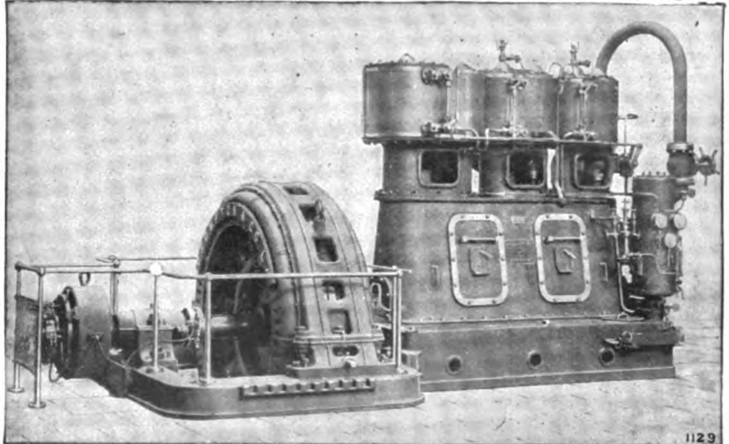

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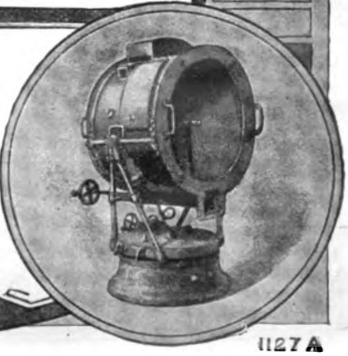

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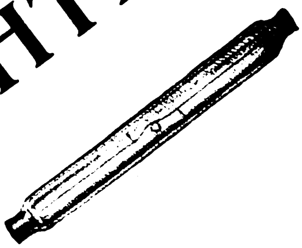

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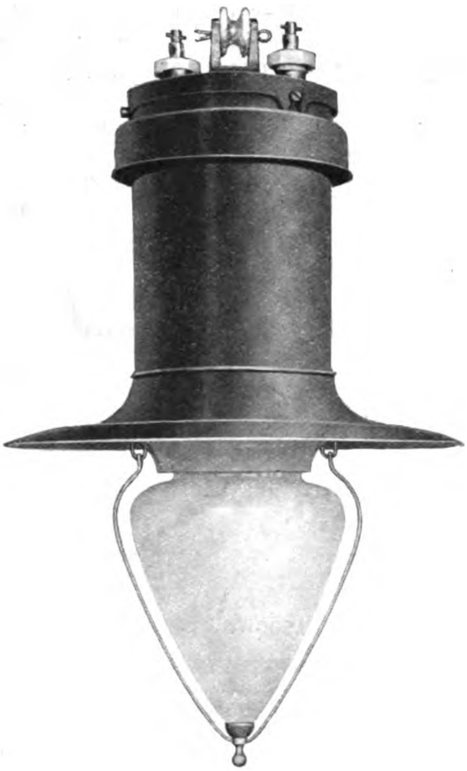

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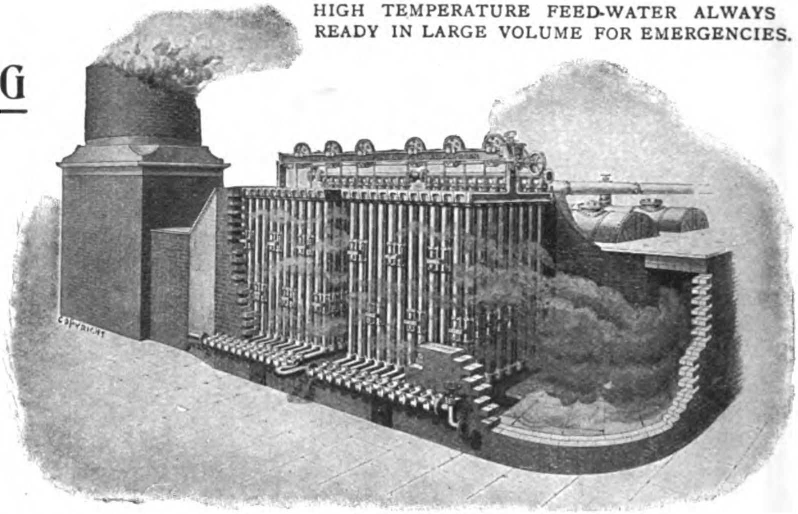

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The

Electrical Magazine.

FOUNDED AND EDITED BY

THEO. FEILDEN.

VOL. VII. No. 6. (42nd Issue.) LONDON. JUNE 26th, 1907.

The World's Electric Progress.

Electric Power in Textile Factories.

WE are pleased to note the controversy which is being keenly followed by correspondents of *The Manchester Guardian* as to the respective merits of steam, gas, and electric power for the driving of textile factories. Apparently there is in the manufacturing districts of Lancashire and Yorkshire a very great search being made into the possibilities of the electric motor in this direction, and the real truth of the matter is to be ferreted out. Some of our electrical contemporaries have been impelled into the fray, and as could only have been expected they have effectively met the arguments of the steam and gas advocates. But it is a very wide subject, and there are so many conditions peculiar to individual factories or districts that the absolute superior value of the electrical drive over all others cannot be stated in so many figures. In fact it would be as easy for us to take exception to some of the claims of the electrical partisan as to those of the man who favours steam and the old-fashioned methods.

We would fain have entered into the discussion here, but, as said, no conclusive or generally useful arguments and statistics on this subject can be put into tabloid form. We have not the space at this writing to do anything more than make a promise and to remind our readers that practically the whole of the next issue of THE ELECTRICAL MAGAZINE will be devoted to the thrashing out of this vastly important question. Our July number will be specially enlarged to accommodate, in one cover, all the main points and side issues of the subject of Electric Power for Textile Factories: what the motor has done, can do, and will do, for the mill owner; where, when, why, and to what extent electricity is to be preferred over all other power agents; the supervision, maintenance, and all costs of the competing systems—and so on. All these have everything to do with this great controversy, and it is our intention to produce a treatise of the subject which will by its very thoroughness carry conviction wherever it goes.

Experts in electrical power engineering, textile machinery, and mill-management are contributing the best fruits of their experience and knowledge. Yet we would have our readers know that any information they can supply to us on the subject will be cordially welcomed. Our special Textile Number is to be as complete and thorough as it is possible to make it. We invite manufacturers, buyers, and users of textile, electrical, and general power engineering plant and appliances to assist us in this work to the common benefit of all concerned in two of the most important industries of this country and the world, the textile and the electrical industries.

❧

Bolton's Electrical Progress.

THE accounts of the Bolton Corporation Electricity Department for the past financial year are exceptionally pleasing, and should be carefully noted by all Central Station men as a guide to what can be accomplished by able management and by forceful enterprise in promoting the sale of current.

During the year ending March 1905 the total number of units sold amounted to 5,458,629; the following year the aggregate reached 6,055,551 units—the past year's records show a noteworthy leap to 8,152,052 units. Looking into details of these figures it is noticed that whereas private lighting developed at an average rate, the tramways department as a customer showed an increase of about 11 per cent. in its demands as against an average increase of about 2½ per cent. for preceding years; it is, however, in the motor supply that the greatest improvement is noticed; the previous year's records showed an increase of about 42 per cent., this was raised last year to 115 per cent., the actual aggregates for the past three years being 1,000,348, 1,423,759, and 3,065,824 units respectively.

The works cost per unit generated has reached the low figure of 0.438d., having been reduced gradually from 1.169d. since the year 1901, when Mr. A. A. Day, the borough electrical engineer, took up his position. The total inclusive cost per unit generated, including charges for interest, depreciation, and sinking fund now stands at 1.159d. as against 2.292d. per unit in 1901. The effective result of this development and efficient working is that the accounts show a gross profit of £32,837 (including £687 carried forward in 1906) for the past year's work. Of this profit £7186 goes to paying interest, £14,033 to depreciation, £3204 to special depreciation, £6000 to the aid of the borough rates, and £3100 is carried forward.

The present capacity of the generating plant is 6800kw., in 1901 it was only 2800kw.: the gross capital expenditure on the works up to March 31st of this year is £292,272.

It is interesting to note that the average prices obtained per unit are: for private lighting 3.43d., for motors 0.933d., and for the tramway service 1.1d. This last figure may appear somewhat high, but the Bolton tramways department is also under the direction of Mr. Day, and considering this charge for current, the tramway accounts show good results. The tramway total income for the past year amounts to £111,294, of which £49,731 is net revenue. The total capital of the tramways system up to date is £471,760.

The accounts under review present a distinct object lesson to many other municipalities. The undertaking under the able management of Mr. Day stands out sharp and clear as worthy of special notice.

❧

The Moore Light.

In the Lighting Section of this issue we have gone at length into a description by the inventor of this remarkably ingenious practical outcome of a well-known laboratory experiment. That it is ingenious and, more important by far, practical, we have, in the completed installation at the Savoy Hotel, London, indisputable evidence. The Moore Light shows itself there as an accomplished fact. Perhaps it will not appeal at first sight to the general public; extra high-tension currents and long tubes of glass do not immediately inspire confidence; but, on the other hand, an efficiency of one watt per candle power and a light beautiful in colour and diffusion will awaken the interest of all inquiring minds. Looking into details one finds that the high tension is absolutely out of reach and insulated beyond the possibility of shock or accident, that the glass tube is tough and of just the right form for placing out of harm's way and yet in the best position for effective lighting results. Moreover the light is available without any special machine or moving mechanism being introduced; it is switched on and off with immediate results by a simple hand switch. All this we know of it—time will tell as to its general reliability, and it would seem, so far as one can possibly judge, that it will prove to be not wanting in this respect.

For offices, large halls, galleries, shops, and public buildings generally there is an immediate field for the new light; the results therein will decide as to its merits for general private lighting installations. There is a feature connected with it also which is of the greatest importance—wiring and the wireman's accessories are practically unrequired. When the Moore light comes into general use the wheel of fortune will give another turn and the wireman *ex* plumber will be pleased to again adopt plumbing as a trade; but this time it will be *glass plumbing*, as the welding and installation of the Moore tube has already been designated, and not inaptly.

⁂

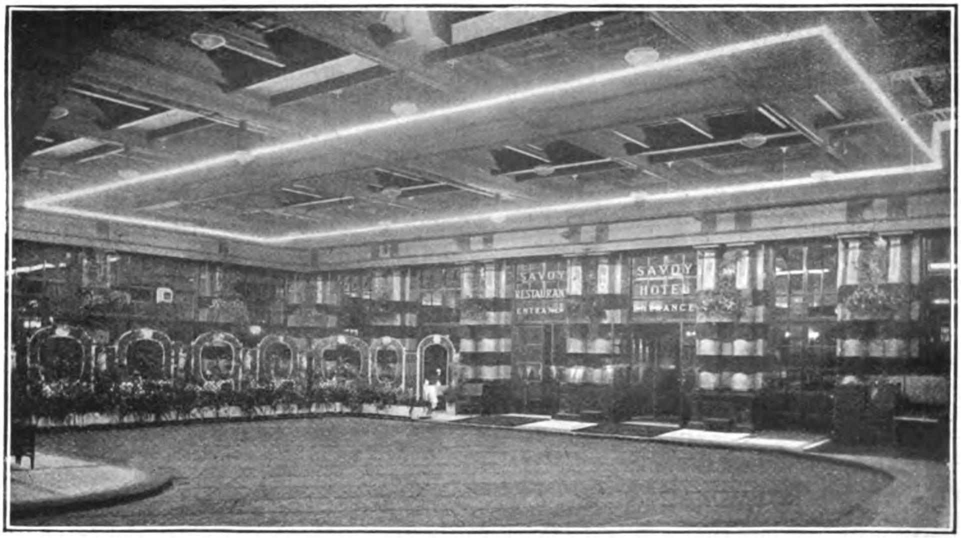
Confidence in Business.

THE keyword of the post-luncheon speeches made on the occasion of the eighteenth annual sports of Messrs. Crompton & Co.'s Arc Works, Chelmsford, held on the 15th inst., was *confidence*. Excepting the weather, which was somewhat disappointing, the affair was a great success, and fully confirmed the remarks of Colonel Crompton as to the exceptionally good feeling 'twixt employer and employed which characterized this leading electrical works. In his speech the gallant colonel told how in 1896, the old factory having been burnt out, he acted upon a strong personal conviction that his new works should be set up where home comforts and healthy surroundings were assured for the workpeople. The result of this was the Arc Works at Chelmsford, and Colonel Crompton publicly expressed his gratification with the result after eleven years' work under these rural conditions.

It was good to hear this leader of British electrical enterprise indicate how each year had increasingly demonstrated the industrial and social success of the move; the master and the man had in this case full confidence in each other, capital and labour were in harmony with each other, and in no other engineering works would it be possible to find happier or more comfortable conditions general amongst the employees.

This was one phase of the confidence essential in business. Another aspect was touched upon by Mr. John Trotter, who dealt broadly with the ruling conditions of capital and labour in bulk. Regarding capital as an essential, it could only be promoted by public confidence in the soundness of the particular industry, which soundness depended largely upon Government policy and the attitude of labour. Speaking of the former factor, Mr. Trotter approached very near to politics, and it will suffice here to say that, in regard to the Liberal Administration, his tone was not distinctly appreciative; regarding the latter factor, he voiced the old truism which is, even in this enlightened age, so slow of acceptance—that capital and labour are indivisible, or rather inseparable. As we have seen, he could not but feel that in the case of Messrs. Crompton's the labour question was happily placed.

Speaking of the keen competition now ruling electrical manufacture led up to the subject of rates, and it was interesting to learn that one of the factors which decided the choice of works site had been the low rates of Writtle, just beyond the Chelmsford



THE FIRST BRITISH INSTALLATION OF THE MOORE LIGHT. THE COURTYARD OF THE SAVOY HOTEL, LONDON.

borough boundary, wherein the works are placed. Since the works came into existence, notwithstanding the immense benefit of their presence to the locality, the works rates had been ever on the increase until they were now excessive. The Mayor of Chelmsford, who occupied the chair, came as a veritable comforter with the news that there was a great probability of the Chelmsford borough being extended in the near future, in which case the Arc Works would become a part of the town and enjoy its much lower scale of rates.

Previous to lunch the party made a hurried but none the less very pleasurable inspection of the works. It was gratifying to note the great quantity of work in hand, and to which we cannot at this writing do justice. In general it was noticed that the several shops and departments were very well arranged, and the disposition of the machines and works sections combined with the splendid roof lighting and airiness of the buildings to form a worthy example of what an engineering works should be, and to which we hope to give our readers a full insight in a subsequent number.

◆

Wood Preserving.

WE have received the following letter from a correspondent relative to the question of the preservation of timber :

SIR,—The article, by Mr. J. J. Kessler, in THE ELECTRICAL MAGAZINE for May, on the preservation of poles and timber, is most instructive, and though his conclusion, that in order to permeate the wood with such materials as shall prevent decay and the growth of micro-organisms, it must be impregnated with water-insoluble substances under pressure, is slightly erroneous, he, of course, confines his remarks to impregnation with metallic substances which have no natural affinity for wood.

Much attention has of late been drawn to a process which employs for the purpose of preserving wood the by-products of sugar refineries. Wood and sugar have a distinct affinity with each other, so that if wood is boiled in a solution of sugar and water, the whole being subsequently cooled, the boiling part of the process drives out the air and moisture from the wood, while in cooling the solution is absorbed and permeates to the centre of the wood. Although sugar is of so soluble a nature, it enters into vital union with the tissues of the wood and it cannot afterwards be parted from them. By impregnating wood under pressure, the fibres are necessarily disarranged and the strength of the timber is as a consequence impaired. Under the Powell process, the name given to the saccharine treatment of wood, there is, on the contrary, a slight increase in tensile strength, owing to the fact that there has been no mechanical force applied. When this process is more widely known it will undoubtedly become one of the leading methods for the preservation of wood from decay.

SAMUEL JOHNSON said:

> "*Knowledge is of two kinds: we know a subject ourselves, or we know where we can find information upon it.*"

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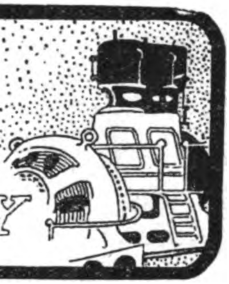


Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Power, its Generation, Transmission, and Distribution.

* * *

Machine-made Ferro-Concrete Poles.

WOODEN poles suffer from a lack of durability owing to their liability to be attacked by rot. Arrangements for protecting them from the action of moisture are employed, but do not entirely overcome the difficulty. Steel masts, whether of tubular or lattice pattern, are free from this objection, but their initial cost is heavy, and the cost of periodical painting to protect against rust is also considerable. Attempts have been made to employ reinforced concrete masts made by hand, but the weight of such solid masts has to be so considerable to afford sufficient strength that the cost of transport, especially in mountainous districts, becomes great, and even prohibitive.

Herr H. Siegwart, of Lucerne, the inventor of the Siegwart beam, has now designed a type of reinforced cement mast which is prepared entirely by machinery. The mast is a hollow tube, with walls from 2.5cm. to 5cm. in thickness, and it may be made to taper to any extent, or given any desired amount of entasis. The reinforcement consists of longitudinal round iron, or steel rods, bound together by continuous spirals of wire. A mixture of coarse sand and Portland cement is used for the construction of the walls. A special machine has been designed for the construction of the masts. The cement mixture is fed by means of an automatically regulated hopper on to an endless band, which applies it to the metal skeleton under a constant pressure. The mixture is thus spread on the skeleton in the form of a spiral band of constant thickness. The inner core is formed by a conical steel tube, slit longitudinally and

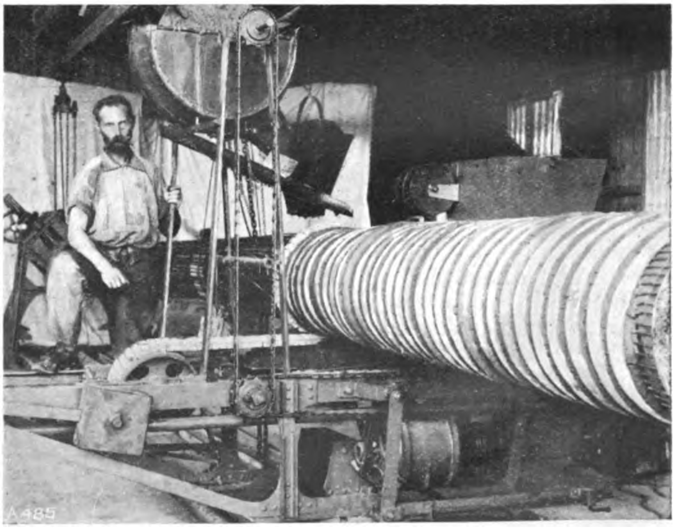


FIG. 1. SIEGWART POLE UNDER CONSTRUCTION.

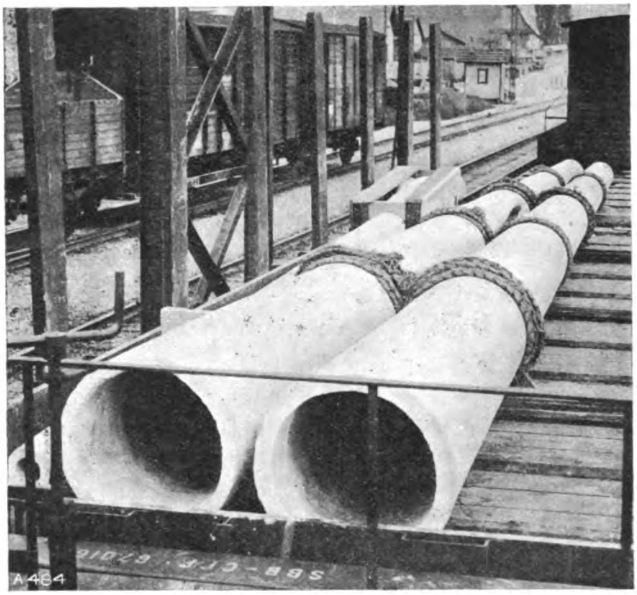


Fig. 2. Siegwart Ferro-Concrete Poles.

kept at a constant distance from the reinforcement. This core is withdrawn when the mast is completed. The machine is electrically driven, and all the movements are regulated by means of adjustable gearing. The spiral band of mortar at first deposited by the belt is rectangular in section, but as the belt is followed up by a former, this section is deformed, becoming lozenge-shaped, so that each turn of the spiral is intimately united with the next. At the same time an external reinforcement is applied in the form of a spiral wire. The mast is then wound spirally with textile material, in order to preserve the original conditions of moisture during setting. A pressure roller is then passed along the finished pole, consolidating the mass. The complete mast has the form of a tube, smooth inside and out. For the purposes of tramway poles in towns, &c., a cement socket of suitable design may be moulded on.

In a test in which a mast 7.25 metres (25ft. 6in.) long was clamped at one end and a transverse pull applied at the other, fracture occurred at a load of 1300kg., giving a factor of safety of 5.5.

[The above description is abstracted from a recent number of *Concrete and Constructional Engineering*, to whom we are indebted for the use of the two interesting illustrations.]

Electrical Fire Engines.

It seems strange in these days when electric power is always available everywhere in a large city that advantage should not be taken of it for driving the pumps employed for fighting fires. The method to-day most widely used is a steam-driven pump drawn by horses. A promising improvement is the introduction of the mechanically propelled fire engine, but although this seems to be meeting with much favour only few of them are as yet in use. They, of course, have very great advantages over the horse-driven vehicle.

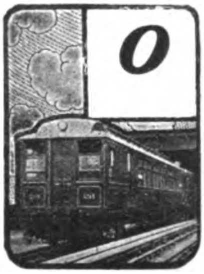
But it is another feature of the fire engine to which attention is directed in *The Electrical Review, N.Y.* The equipments at present in use consist of a steam pump and a rapid-steaming boiler. These equipments are necessarily heavy. Moreover it is necessary to keep up steam within the boiler, and the latter is always dependent upon a supply of fuel. If the boiler and engine were done away with and replaced by an electric motor with suitable cables for drawing its electric power supply from the city mains, a much lighter, and, what would be of the greater advantage, a much more powerful pump could be adopted.

Such an electrical fire-engine would be entirely independent of fuel supply and ready to start at any moment. It could work continuously with practically no noise, and give off no smoke to interfere with the work of the men. An outlet for securing electric power could be installed at every fire plug, and connection with the electrical supply would be a simpler and quicker operation than connecting on the water hose. The reliability of the supply could be easily insured by arrangement with different power-houses in the city, but there is little likelihood of trouble on this score, as most power systems in large cities have not had any failure of supply for ten years or more past.

A classified list of Traction and Transport articles will be found in the World's Electrical Literature section.

Some Facts and Problems Bearing on Electric Trunk-line Operation.*

FRANK J. SPRAGUE.



ON all services high continuous capacity of the motor is essential.

Capacity being the keynote of the equipment, the author will discuss the characteristics of conductors and motors used with direct current and with alternating current. In so far as the comments relate to single-phase, alternating-current operation, they will in some measure be based upon the only existing commercial development of this character now in the United States; that is, upon the series-wound, commutating, single-phase motor with compensated fields, operated at 25 cycles. Lowering the number of cycles to increase the capacity of the single-phase motor, as has been suggested although not yet developed in commercial practice, of course merits serious consideration, and the author will add some comments upon this proposed change.

Behaviour of Conductors.—Both motors and conductors, when used for direct current or for single-phase alternating current, present certain differences of such inherent character that there seems no present likelihood of material change, and this conclusion is as sound in regard to the motor differences as it is in regard to conductors. When used for single-phase alternating currents, conductors offer, by reason of self-induction, an impedance or resistance to current materially greater than they present to direct currents. This impedance, and the consequent loss of energy at any particular potential delivery, depends upon the shape and material of the conductor, upon the frequency of alternation, the density of current, and the power factor. Under ordinary conditions, a round copper conductor of, say, No. 0000 size, has at 25 cycles an impedance of about 1.6. But with iron or steel conductors this impedance is increased many times, because the magnetization of the iron and the self-induction drive the current toward the skin of the conductor, so that the body of it is useless, and it might as well be a shell of very much less weight.

This effect in steel rails increases with the quality and with the cross-section of the rail. For example, according to the report of the test commission of the recent International Electrical Congress, on 50lb. traffic rails the ratio of impedance to direct-current resistance at 25 cycles and 300 amperes is about 5.4, while on 80lb. rail this ratio with the same current is 9.0, with the curious result that increasing the cross-section of the rail does not apparently increase its actual capacity for carrying single-phase currents. Quite the contrary, of course, is the fact in regard to direct currents, the conductivity increasing with the cross-section and quality.

These statements are made, not because of special novelty, but, in emphasizing certain inherent differences in conductors in their behaviour toward the two kinds of current, additional weight is lent to the statement that the differences inherent in direct-current and single-phase alternating-current motors are likewise radical and are probably permanent in character.

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* Abstract of Paper read before the Amer. Institute of Electrical Engineers, May 21, 1907.

Types of Motor.—Among the many types of motors proposed for railway service four are now being exploited: Polyphase alterna ting-current motor without commutator; single-phase alternating-current motor without commutator; single-phase alternating-current motor with commutator; and direct-current motor with commutator.

Of these, two, the direct-current and the three-phase motors, each have a continuous rate of energy input, while the single-phase motor has an intermittent and variable rate. Moreover, there is combined in the single-phase motor two distinct functions, those of a motor and a transformer, and the latter cannot be entirely eliminated. The result is a reduction in both continuous and overload capacities.

It is in this particular that the single-phase motor, despite a great amount of experimental development, has remained defective; and while not prohibitive to the extent of making it an unworkable machine, its defects are so inherent as to place it at a serious disadvantage in individual comparison with other types of motors. To attain the pre-eminence hoped for, the external advantages in current supply must be very marked. In fact, rated in the same manner and under like physical conditions, it is only about half as good as the direct current motor. Or to put it another way, the weight of the complete single-phase electrical equipment on a car or locomotive, including transformers, motors and controlling apparatus, for continuous hard service, and with like physical limitations and ventilation, is about twice that required for direct-current apparatus. In addition to this there is, of course, a material increase in the mechanical equipment necessary to carry the electrical apparatus. The reason is simple—it is because of the heat generated on account of lower electrical efficiency, and the working the fields of the motors at a reduced magnetic flux.

When considering locomotives, the net result is that the total weight of a single-phase alternating-current locomotive, with a service capacity equal to that of a direct-current locomotive of like armature speeds and permissible temperature-rise (this temperature-rise being the ultimate limitation of a motor for continuous service) will easily be from 30 to 50 tons more.

An increase in the total weight of a train amounting to from 3 per cent. to 10 per cent. is perhaps not of itself of so much importance, because such a difference in net power demand can easily appear for various reasons; but a ratio of 2 to 1 in capacity for the limit of equipment possible to install within given allowable dimensions and number of units is a matter of vital importance.

If an increased weight is permissible for any given capacity, there must be some ample compensation for it. Of course, this is claimed to be the fact in the single-phase system, but another possible advantage which might prove important is the abolition of gearing and bearings, and simplification in motor and locomotive construction.

Comparative Weights of Direct-current and 25-cycle Single-phase, Alternating-current Motors.—While testimony is practically universal that not only is any single-phase motor, whatever the number of alternations, more or less inefficient than a direct-current motor of like weight or capacity, the differences of efficiency, excluding the losses in the gearing, are variously estimated.

The curves on page 369, Fig. 1, show a comparison between a 125h.p. d.c. motor and an a.c. motor of the same weight. The comparison also includes the "weight-coefficient," which for convenience may be expressed by the following equation:

$$\text{Weight coefficient} = \frac{\text{Nominal rated horse-power}}{\text{Revolutions} \times \text{weight in tons}}$$

This is a factor of the greatest importance, and it should be considered not only for the one-hour 75deg.-rise load, but throughout the whole thermal curve.

Generally speaking, it will be noted from these curves that, starting at 500 revolutions for a thirty-nine-minute run, the capacity of the direct-current motor averages approximately nearly double that of the alternating-current throughout the thermal range; the speed of the alternating-current motor rises at a much more rapid rate, until on a five-hour run it is double that of the direct-current-motor, despite the fact that it is only developing one-half the power; the direct-current motor has a five-hour capacity in excess of the one-hour capacity of the alternating-current motor; and the ratio of the weight-coefficients, beginning at a trifle over 2 to 1, rises to more than 4 to 1 in favour of the direct-current motor on the longer runs. This comparison of weight-coefficients does not include the collectors, control switches, rheostats, transformers, or wiring, which in the aggregate are enough heavier for the alternating-current motor to maintain these disparities.

It is evident, therefore, that a pair of these alternating-current motors can handle only about one-half of the total load of the direct-current motors, with all the disadvantages of higher armature speed and smaller air-gaps; and considering the excess weight of the control apparatus, the net load over and above the electric equipment would be considerably less than one-half.

The general comparison is not, so far as the relative characteristics are concerned, individual to this particular size of motor, but seems to be equally applicable through a wide range, and indifferently as to the make, or whether the alternating-current motor is of the series-compensated or the repulsion type. Furthermore, these differences are seemingly so inherent that there is little chance for improvement at 15 cycles.

Difference between direct-current and single-phase alternating-current motors.—The inherent differences between single-phase and direct-current motors may be briefly summed up as follows:

1. The input of current in one is continuous; in the other intermittent.
2. One has a single frame, the electrical and mechanical parts being integral; the other has a laminated frame contained within an independent casing. Hence there is not equal rigidity or equal use of metal.
3. One has exposed, and hence freely ventilated, field-coils; the other has field-coils embedded in the field magnets.
4. One has a large polar clearance, and consequently ample bearing wear; the other has an armature clearance of about only one-third as much, and hence limited bearing wear.
5. One is operated with a high magnetic flux, and consequently high torque for given armature-conductor current; the other has a weak field, and consequent lower armature torque.
6. One has a moderate-sized armature and commutator, and runs at a moderate speed; the other, with equal capacity, has a much larger diameter of armature and commutator, and runs at a much higher speed.
7. One permits of a low gear-reduction, and consequently a large gear-pitch; the other requires a higher gear-reduction, and a weaker gear-pitch.
8. The windings of one are subject to

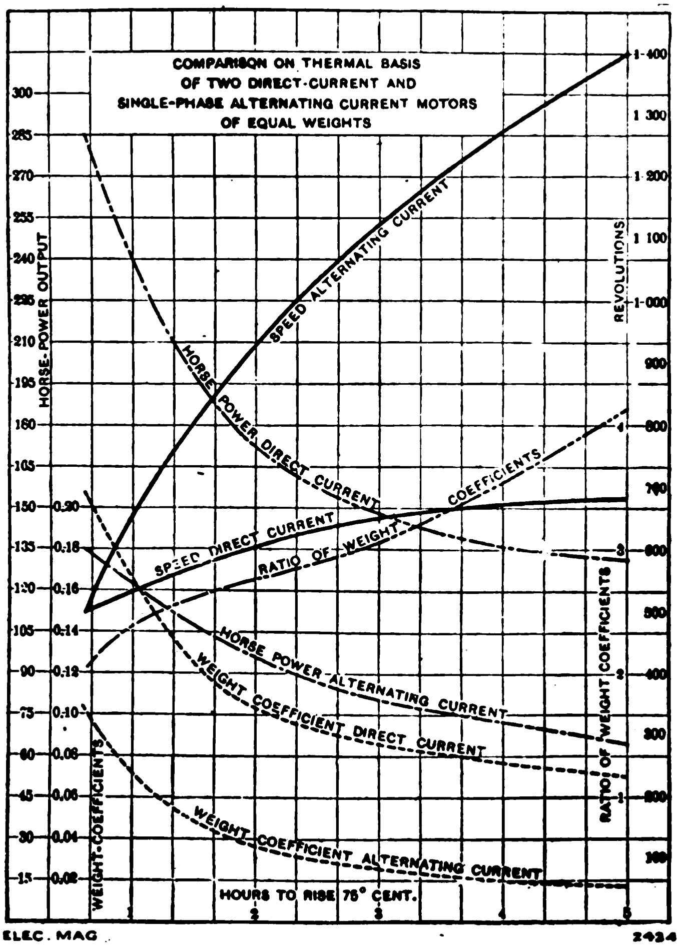

Fig. 1.

electrical strains of one character; in those of the other the strains are of rapidly variable and alternating character.

9. The mean torque of one is the corresponding maximum; the mean torque of the other is only about two-thirds of the maximum.

10. The torque of one is of continuous character; that of the other is variable and pulsating, and changes from nothing to the maximum fifty times a second.

11. One has two or four main poles only, two paths only in the armature, and two fixed sets of brushes; the other has eight to fourteen poles, as many paths in the armature, leading to unbalancing, and as many movable sets of commutator brushes.

12. One can maintain a high torque for a considerable time while standing still; the other is apt to burn out the coils which are short-circuited under the brushes.

13. In one, all armature coil connections are made directly to the commutator; in the other, on the larger sizes resistances are introduced between the coils and every bar of the commutator, some of which are always present.

14. In one the sustained capacity for a given weight is within the reasonable requirements of construction; in the other it is only about half as much.

15. Finally, the gearless type, with armature and field varying relatively to each other, is available for one, but this construction is denied to the other.

Consideration, then, of the characteristics peculiar to each class of motor indicate, not that the single-phase motor cannot be used, but that if adopted the weight or number and the cost of locomotives or motors required to do the work must be much greater; that the depreciation of that which is in motion will be much higher; and that there will always be an excess weight of fixed amount per unit which must be carried irrespective of the trailing or effective loads. We must, therefore, in many cases be led to the selection of the direct-current motor, that motor which has the higher weight capacity, the greater endurance, and the lower cost per unit of power.

Comparison of direct-current and alternating-current braking.—On the general subject of braking it should be pointed out that with direct or continuous-current motors there is always a residual magnetism in the fields because of their construction, and the fact that the exciting current never changes direction. Such machines, therefore, can always promptly build up automatically when properly closed upon themselves and the reverser is set in the proper direction.

A similarly effective method of braking has been claimed for motors operated by single-phase alternating currents, but it would seem that in this case there is not the same degree of reliability. In such motors the field is laminated to the last degree to cut down heat losses and to increase the capacity: it will hold but little residual magnetism under any circumstances, and furthermore, the field is excited by a rapidly varying alternating current. It is, therefore, possible that at times the field will be nearly inert, and comparatively slow, with its low-turn winding, in building up, or possibly the field may be entirely inert, and may refuse to build up at all. There seems, therefore, no certainty whatever that a single-phase alternating-current motor, disconnected from the line, and without any other exciting source, will, when closed upon itself, always build up into a braking dynamo.

Aside from the ordinary objection of having such a possible failure, the consequence might be serious should it be necessary suddenly to call upon the machines to brake; as, for example, when getting under way, or when slowly ascending a grade there should be a failure of current and the train begin to back down before the air brakes were applied, or in case for any reason they should not be promptly available.

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Earth Detector for Three-Phase Circuits.

F. E. CONRAD.

In its simplest form the three-phase earth detector shown in Fig. 1 requires three transformers. These are of the type generally installed in connection with switchboard instruments, and should have a capacity of about 40 watts. The primary side should be wound for the busbar or feeder voltage, and the secondary side should be wound for any incandescent lamp voltage. Suitable fuse blocks should be interposed between the transformers and the bus or feeder-circuit to which they are connected. Fig. 1 shows the diagram of connections. From this it will be noticed that the transformers are connected Y-fashion with the neutral earthed, and with an incandescent lamp connected to each transformer.

The transformers may be supported on a side wall from brackets made of strip-iron, and secured to the wall by expansion bolts. A strip of hardwood supported directly in front of the transformers has the lamp receptacles fastened to it, and is arranged conveniently for the electrical connections. The secondary wires may also be bunched in a cable and run to the lamps, which may then be placed wherever desired. Assuming a bus or feeder potential of 1150 volts and the transformers to be wound for 1150-115 volts, each lamp would receive $115 \div \sqrt{3}$ or 66 volts; and if 115-volt lamps are employed they would burn with a dim light. If, now, an earth should occur on any line, the corresponding lamp would be extinguished, and the other two lamps still burn with a dim light as before.

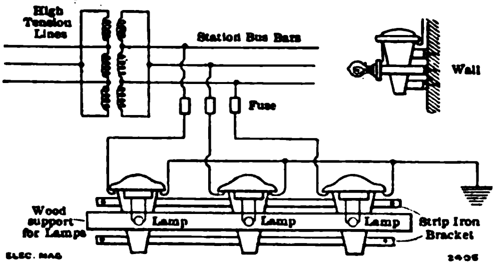

FIG. 1.

If there is a high-tension transmission-line connected to the bus through step-up transformers, or in case the ground detector is used on a feeder supplied from a high-tension system through step-down transformers, the ground detector here described has the additional advantage of indicating the condition of the high-tension system, not only as regards a dead ground, but also as regards heavy leakage. This is because any abnormal condition on the high-tension system will cause an unbalancing of the secondary voltages impressed on the lamps. As the leakage increases, the lamps vary more and more from their normal condition of dim burning, until an earth occurs. This will be indicated by one lamp burning at full brilliancy. The second lamp (assuming the same voltages as above, that is, 115-volt lamps receiving 66 volts) will not be quite as bright as normally, receiving only about 57 volts; and the third lamp will be to all appearances extinguished, the voltage on the lamp being approximately 15 volts.

In Fig. 2 is shown a more elaborate earth detector, involving the same principle and having in addition a voltmeter with plug and receptacle for ascertaining the voltage on any lamp. There is also a three-pole knife switch to connect the ground detector on either of two sets of busbars. The addition of the knife switch renders the device unsuitable for installation as an additional panel to the switchboard, as in case of a high potential it would require the running of leads from the busbars to the switchboard, which, of course, would be objectionable and dangerous. It would be better to select a position near the busbars and arrange the device with a view to preventing accidental contact with the bare parts of the switch. Should it be desirable to have the lamps and voltmeter on the switchboard, the transformer and the switch could be fitted in a convenient place and the secondary wires run as a cable to the switchboard. Voltages up to and including 2400 should have a switch with blades spaced about 5in., and the contacts separated by slate or marble barriers. While the current is so small that any tendency to arc would be absent, a switch of this kind would not be suitable to open in case of trouble in the transformers, and the fuses, especially if the busbars carry a large amount of power, should be absolutely reliable.

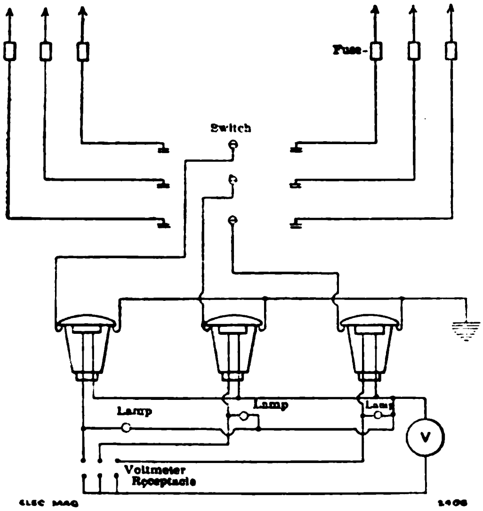

FIG. 2.

A slight variation in the brightness of the light does not indicate serious trouble. For instance, on a 15 or 20-mile transmission line having a potential of about 25,000 volts wet weather may cause the voltage on one lamp to vary 25 per cent. This would disappear when the line became dry again; but should such a variation occur in good weather, it would probably indicate a permanent leak, and an effort should be made to locate the trouble and remedy it before it becomes worse. Unfortunately, the writer has not had an opportunity to note the performance of this detector for a specific case of trouble that developed gradually, such as the burning off of a pin or cross-arm. Of course, no general rule can be given for any specific case, and only observation and a complete record of previous trouble will enable one to judge the extent of the fault causing a certain variation.

Earth faults on the high-tension side may easily be distinguished from those occurring on the low-tension side, because the high-tension trouble always causes a rise in voltage on one lamp. The writer has had very little opportunity as yet to observe the performance of this detector in comparison with the ordinary form of static ground detector during severe lightning disturbances; and while he knows that the one standard make of static ground detector with which he has had actual experience is all right so far as indicating a ground is concerned, he has seen, on the other hand, quite a number of them blown to atoms by lightning discharges jumping from a stationary vane to the moving element which is grounded, passing thence to a stationary vane on another lead, and causing a disastrous short-circuit, which interrupted the service and disfigured the marble panel.—*Electrical World.*

To Swell the Power Load.

Central Station Engineers and Managers in Lancashire, Yorkshire, and All Textile Districts should note that the NEXT NUMBER of THE ELECTRICAL MAGAZINE will be devoted exclusively to

The Use of Electric Power in Textile Factories.

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LIGHTING and Heating

Readers are referred to the World's Electrical Literature Section for titles of all important articles of the month relating to Lighting and Heating.

The Moore Light.[*]

D. McFARLAN MOORE.

SOME years have passed since the author first realised that there then existed no form of artificial light that could truthfully be said to imitate daylight. Believing unalterably that such a light was to be the next logical step of great importance in artificial illumination, he commenced an investigation that still continues.

To duplicate daylight closely, three premises were soon determined upon, and these have never been abandoned:

1. Large light source, the practical solution being a long glass tube emitting light.
2. Use electricity flowing through a gaseous-conductor, not a solid conductor.
3. Perfect imitation of colour values.

Immediately on beginning investigation on these premises, the gaseous-conductor became the factor of greatest importance. The life of the first lamps or tubes constructed was extremely short, since, as then expressed, "the vacuum deteriorated." Up to date, four methods have been developed and used, and thousands of experiments have been made concerning the replenishing of the gas and thereby overcoming this vital difficulty of the gaseous-conductor becoming non-conducting, due to the peculiar chemical reaction that must occur when electricity passes from a solid conductor to a gaseous-conductor. These methods are as follows:

1. By obtaining a cycle of events through catalytic action. The intensity of light possible was found to be very low.
2. Obtaining a cycle by evaporation and condensation. Probably mercury is the only element that can ever be used in this way in glass tubes.
3. By re-supplying the necessary gases automatically by the action of heat on suitable substances.
4. By automatically feeding gas to the tube when needed, which is the method used at the present time.

The present system has passed the experimental stage. It is a result of twelve years of experimenting, but its advance from year to year has always been steady. It is now fitting that an authoritative technical record be made of the essential facts at present connected with it.

For many years all scientists have agreed that a vacuum-tube light would be right theoretically: commercial men who have had their electric lighting bills reduced now know of its practical value.

The illumination by a Moore vacuum tube of the assembly room wherein the paper was read greatly facilitated making clear not only its mechanical construction, but also its many other salient advantages and characteristics. The electrical energy is obtained from the alternating-current street mains.

It was noted that the light emanates with absolute uniformity from the entire area of a single, continuous glass tube 1.75in. in diameter in the form of a large rectangle, 62ft. by 25ft., which is supported on the cove designed to conceal the incandescent lamps. The glass tube is 13in. from the ceiling and 16ft. from the floor.

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[*] Abstract of paper read before the American Institution of Electrical Engineers, April 26, 1907.

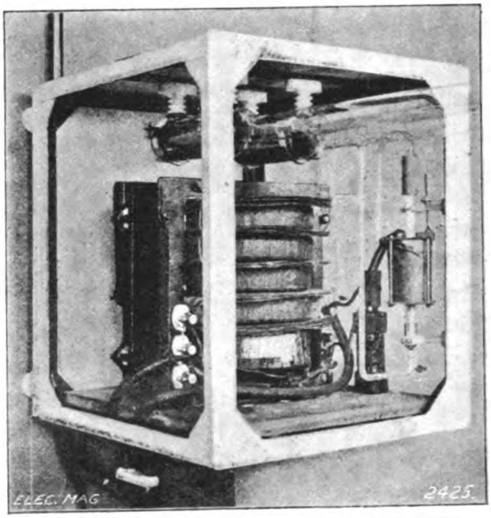


Fig. 1. Interior of Terminal Box.

It is supported by plain brass rings $1\frac{7}{8}$in. in diameter attached to small porcelain insulators inserted in the ends of brass fixture tubes, which, of course, contain no wires.

The two ends of this continuous glass tube approach within a short distance of each other, and then extend horizontally through the wall and into a rigid steel terminal-box. This terminal-box (Fig. 1) contains all the necessary electrical apparatus and is fed by 60-cycle alternating-current at 220 volts. Besides the two carbon electrodes of the tube, the terminal-box contains a step-up transformer and a small specially designed valve with its solenoid, which represents an entirely new departure in vacuum tube lighting, and also one that is vital to its success. The electrical circuits from this apparatus are extremely simple, and are shown in Fig. 2. There is no distributed or high-potential wiring. The high-potential terminals of the transformer within the terminal-box are only two or three inches in length, and are attached directly to the electrodes within the box. All the high-potential wires, therefore, always remain within the box, which has a wire seal placed upon it. A hand can be placed on each of the glass tubes near where they emerge from the two holes in the side of the box, but the glass tubes insulate the gaseous conductor within them so well that no shock can be felt.

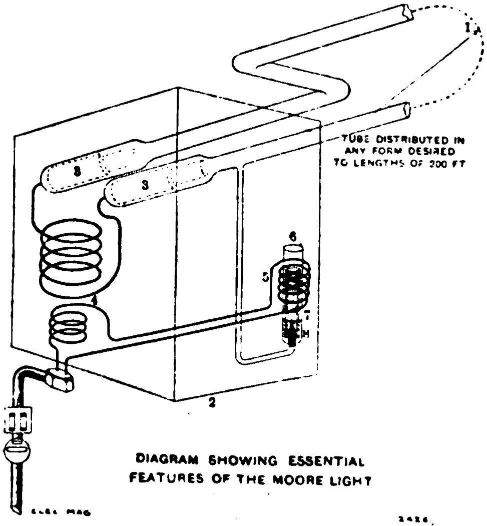

1
TUBE DISTRIBUTED IN ANY FORM DESIRED TO LENGTHS OF 200 FT
8
3
6
5
4
7
H
2
DIAGRAM SHOWING ESSENTIAL FEATURES OF THE MOORE LIGHT
ELEC. MAG
2426.

Fig. 2. Diagram of Connections.

Since the feeder-valve operated by the solenoid just mentioned is an essential feature of this system, a description of its operation will be interesting. Any vacuum tube when commercially luminous will, in a few minutes, seriously alter the degree of its vacuum unless special provision be made to replenish its gaseous-conductor. Due to the flow of current, a portion of the residual gas within the tube is absorbed; that is, it is changed to a solid form, and the degree of vacuum in the tube becomes higher.

This higher degree of vacuum so increases the resistance of the tube that at first the light simply becomes unsteady, but rapidly changes to a condition of violent spasmodic flickering, which soon entirely ceases, and the tube gives no light whatever.

The problem, therefore, was to devise practical means for replenishing the gaseous-conductor of a vacuum tube. This is the function of the feeder-valve which permits air or other gas to enter the tube only when it is needed, and in such a manner that it is entirely automatic. A piece of $\frac{7}{8}$in. glass tubing is supported vertically, see Fig. 3, its bottom end is contracted into a $\frac{1}{8}$in. glass tube which extends to the main lighting tube. At the point of contraction at the bottom of the $\frac{7}{8}$in. tube there is sealed by means of cement a $\frac{1}{4}$in. carbon plug, the porosity of which is not great enough to allow mercury to percolate through it, but which will permit gases easily to pass, due to the high vacuum of the lighting tube connected to the lower end of the plug, and approximately atmospheric pressure above it. This carbon plug is normally completely covered with what would correspond to about a thimbleful of mercury which simply seals the pores of the carbon plug, and therefore has nothing whatever to do with the conducting properties of the gas in the main tube which produces the light. Partly immersed in the mercury and concentric with the carbon plug, is another smaller and movable glass tube, the upper end of which is filled with soft iron wire, which acts as the core of a small solenoid connected in series with the transformer. The action of the solenoid is to lift the concentric glass tube partly out of the mercury, the surface of which falls and thereby causes the minute tip of the conical shaped carbon plug to be slightly exposed for a second or two, and an extremely small quantity of air or other gas filters through it, and then finds its way into the vacuum tube proper. In normal operation, most of the tubes expose this carbon tip for about one second every minute. Therefore, this system, broadly speaking, consists in continuously burning air electrically.

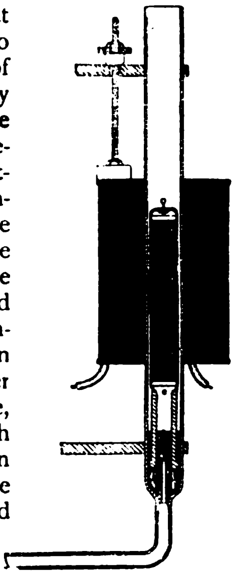


Fig. 3. The Automatic Valve.

Fig. 4 will explain the theory of this action still more clearly. This curve shows the relation between conductivity and degree of vacuum. Of course there must be a critical degree of vacuum at which the conductivity is a maximum; this point corresponds to *X*. By means of the adjusting screw at the top of the solenoid the degree of vacuum is kept normally at a lower vacuum corresponding with *Y*, therefore as the electricity uses up the gaseous-conductor, the vacuum, of course, becomes higher, the conductivity better, and a greater current flows through the solenoid causing it to lift the displacer and expose the carbon tip above the surface of the mercury. Immediately upon the air being admitted the vacuum falls, its resistance increases, and the current through it decreases as does also the current from the mains; therefore, the feeder magnet weakens and the displacer falls, thereby shutting off the air or gas inlet. This cycle is repeated about once a minute throughout the life of the tube, which is indefinitely long. Of course when the tube is not in service there is no leakage of air or other gas through the mercury covering the plug.

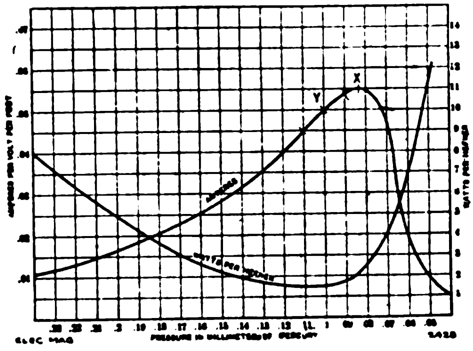


Fig. 4.

The following comparative illumination tests were made between the Moore tube located in the lobby of a large theatre and the incandescent lamps formerly used to light the same area.

Illumination Measurements in Hefner Feet in the Lobby of a Theatre.

Station.	Moore Tube.	Incandescent System.
1	0.795	1.05
2	2.33	1.05
3	6.48	1.27
4	4.38	1.25
5	3.48	1.25
6	3.81	1.34
7	3.20	1.05
8	3.30	1.34
9	2.86	1.02
10	2.73	0.88
11	2.20	0.74
12	1.19	0.52
13	3.39	1.14
14	3.47	1.14
15	2.96	1.25
16	3.30	1.31
Mean illumination (average hefner-feet of 16 stations).. ..	3.12	1.09
Average variation from mean ..	27%	16%
,, volts..	222a.c.	115d.c
Amperes	21	51.75
Watts total	3075	5470
Power-factor	66	—
Area square feet	2110	2110
Watts per square feet	1.46	2.82
Illuminating efficiency $\frac{\text{Mean hefner-foot}}{\text{watts}}$	2.15	0.39

Therefore the tube system has 5.1 times the illuminating efficiency of the incandescent lamp system under the same local conditions. The useful illumination has been increased 450 per cent., yet the current consumption is reduced 45 per cent.

If this tube had been longer its efficiency would have been still better, and by equipping it with a simple white reflecting enamel on the exterior of its upper half it would have had the benefit of a reflecting surface like most other forms of light in normal operation. Measurements of tubes so equipped show an efficiency corresponding to less than one watt per hefner and therefore approaching the theoretical limit for a light of such a commercially good spectrum.

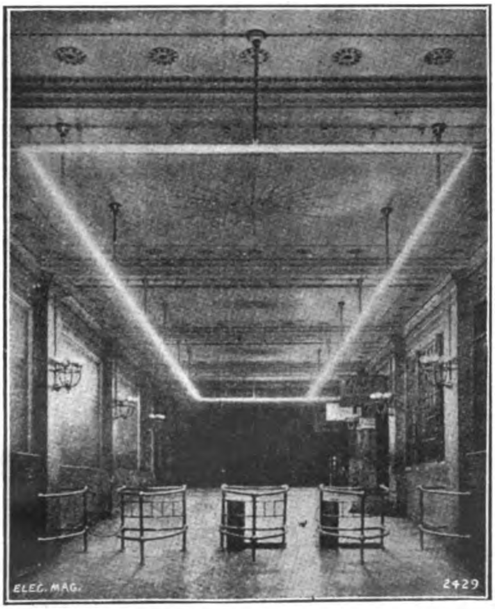


FIG. 5. MOORE LIGHT INSTALLATION IN THE LOBBY OF A THEATRE.

The entire basement floor of a department store, which is solely lighted by four tubes each about 200ft. in length, was formerly lighted with enclosed alternating-current, 6-ampere, 60-cycle arc lamps. The goods are generally displayed on tables and shelves on the side walls, and the plane of photometric measurement was chosen at the average height of the tables; that is, 36in. from the floor.

The ceiling is 10ft. 3in. high and coated with gray paint. The tube is 199ft. long, operating directly from the 60-cycle street mains; that is, there are no auxiliary devices to be taken into account as with some other forms of light. The centre of the tube is 8ft. 9in. above the floor and the centre of the arc lamp 8ft. 6in. above the floor. It was noted that various articles are suspended from the ceiling in this department, and that with the tube light the ceilings and walls were well illuminated, while with the arc lamps, due to their reflecting shades, the ceilings and walls were very dark.

The following comparative illumination tests were made between tube "B" when fed with pure nitrogen and therefore giving a yellow light, and the nine arc lamps provided with 15in. white opalescent reflector shades formerly used to illuminate the same area.

ILLUMINATION MEASUREMENTS UNDER TUBE "B," DEPARTMENT STORE.

STATION.	MOORE TUBE.	ARC LAMP SYSTEM.
Vert. 1..	2.84	1.30
2..	1.76	1.14
3..	4.66	1.25
4..	2.02	0.68
5 .	2.84	0.59
6..	3.75	0.75
7..	1.34	0.45
8..	1.91	0.68
Vert. 9..	1.09	0.79
10..	4.30	3.30
11..	2.24	2.80
12..	1.71	1.06
13..	2.64	1.72
14..	2.16	1.31
15..	3.73	1.08
16..	2.14	1.33
17..	2.02	0.45
18..	2.24	1.02
19..	2.24	1.42
20..	1.82	0.73
21..	2.56	0.82
22..	5.05	0.79
Mean illumination (average hefner-feet of 22 stations)..	2.6	1.16
Average variation from mean	31.8%	40.4%
,, volts..	230	122
Amperes	24	53.1
Watts total	3500	4500
Power factor..	62.5%	70
Area square feet	3753	3753
Watts per square feet	0.93	1.2
Illuminating efficiency $\frac{\text{Mean hefner-foot} \times \text{area}}{\text{watts}}$	2.79	0.967

Therefore the tube system with yellow light has 2.9 times the illuminating efficiency of the enclosed arc-lamp system under the same local conditions.

The useful illumination has been increased 220 per cent., yet the current consumption reduced 22 per cent.; this amounts to a saving of 10 cents per kilowatt-hour. At 65 hours per week this means $338.00 per year on this one tube. On the four tubes for the entire basement it means a saving of $1350.00 per year.

On account of the remarkable colour qualities of the white Moore light, a request was made to change two of these yellow tubes over the china department to a white colour, and the following comparative illumination tests were made between tube "C," 211ft. long, when fed with pure carbon dioxide gas, and therefore giving a white light, and the ten 6-ampere, 60-cycle arc lamps provided with 12in. spherical opalescent globes.

ILLUMINATION MEASUREMENTS UNDER "C" TUBE, BAMBERGER BASEMENT.

STATION.	MOORE TUBE.	ARC LAMP SYSTEM
1	0.91	0.34
2	1.71	1.73
3	0.89	0.36
4	0.75	0.40
5	1.06	0.63
6	2.18	1.51
7	1.31	0.97
8	0.47	0.45
9	0.49	0.29
10	1.11	0.51
11	1.96	0.54
12	0.88	0.57
13	0.66	0.23
14	0.63	0.32
15	1.71	1.11
16	1.25	0.43
Mean illumination (average hefner-feet of 16 stations)	1.12	0.65
Average variation from mean ..	37.5%	51.7%
" volts	227	122
Amperes	42	59
Watts total	5750	5000
Power-factor	61%	70%
Area square feet	4275	4275
Watts per square feet	1.34	1.17
Illuminating efficiency $\frac{\text{Mean hefner-foot} \times \text{area}}{\text{watts}}$	0.83	0.55

Therefore the white tube is 1.5 times more efficient than the enclosed arcs.

The delicately coloured china ware is now exhibited under exact daylight conditions and the general illumination is a marked improvement over that furnished by the arc lamps. The fact should be emphasized that the arc lamps hung much lower than the tube and produced a bad effect. The arc proper of the arc lamps was 28 per cent. nearer the plane of measurement than the tube. With the tube there located it would also show an economy over the arc lamps of about 78 per cent.

Although the above tests indicate that this system is now the most efficient light source known, nevertheless not only theory but experiments already made show that greater advances in efficiency are yet to be made. The best gaseous-conductors particularly adapted for selective radiation must be determined upon. For example, nitrogen has about twenty times the efficiency of hydrogen. A gaseous-conductor must also be selected that not only has proper colour values but must maintain high efficiency over wide ranges of intensity; for example, mercury vapour (to say nothing of its colour) is very inefficient in the long-tube system. It is only efficient at intensities which should be considered too high, and which is also the reason why the mercury tube is so sensitive to temperature changes.

Moore tubes are now used in lengths varying from 40ft. to 220ft. The following curves, Fig. 6, show the watts per hefner for 40ft. to be 2.5, and for 220ft. to be 1.4, on the basis of a yellow light. Therefore, when tubes are operating at 12 hefners per foot, which is the average intensity now used, tubes from:

40 to 70 feet use a 2 kw. transformer.
80 " 125 " " a 2.75 " "
130 " 180 " " a 3.5 " "
190 " 220 " " a 4.5 " "

In order to ensure a steady light the power factors of the circuits supplying these transformers average at present 65 per cent. This is obtained either by using a shell-type transformer of special design with a leakage reluctance of about 65 per cent., depending on the size of the transformer required, or there can be used a standard type of core transformer, operated in series with a special type of adjustable inductance, consisting of two composing coils on the centre leg of an iron core of the shell-type formation.

Feeder-valve solenoids of four sizes have been found sufficient, and are usually connected in series with the low-tension circuit of the transformer and inductance, although they are sometimes operated by the high-tension circuit.

Although the average power-factor is now about 65 per cent., there is no theoretical reason why all these tubes should not operate at a considerably higher power factor. In fact a very recent improvement in the valve which has entirely eliminated capillary attraction, has made it practical to adjust tubes to a power-factor as high as 84 per cent.—which is a decided improvement over some of the first tests published, and makes the tube far better than either the alternating-current motor or the arc lamp in these respects. Since all the electrical factors of the entire system are based on the conductivity of the gas column, it is possible to vary the power-factor over a wide range simply by changing the degree of vacuum by regulating the amount of gas fed to the tube.

The curves on the next page show the

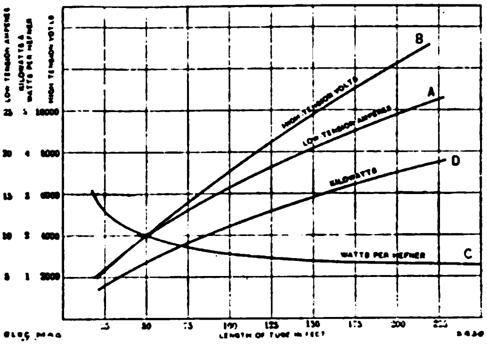


FIG. 6.

relations existing between the salient factors that have to do with the tube performances.

Curve *A* shows how the amperes of the low-tension side of the transformer at 220 volts vary with the length of the tube.

Curve *B* indicates that the actual voltage on the tube terminals for 40ft. is 3146, and for 220ft. 12,441 at 12 hefners per foot.

Curve *C*. Since the no-load transformer losses and also electrode losses become a larger percentage of the total watts as the tubes are shorter, therefore the watts per hefner grow less: that is, the longer the tube the better the efficiency.

Curve *D*. Doubling the length of a tube does not double the kilowatts required.

Curve *E*. These tubes soon become seasoned; that is, use up all foreign gases, and then their intensity remains perfectly constant for an indefinitely long period of time.

Curve *F*. The efficiency also remains constant.

Curve *G*. The efficiency does not vary over a wide range of supply voltage.

Curve *H*. The light intensity is directly proportional to the voltage, not as the square or the cube of the voltage, as is the case with incandescent lamps. This is an advantage of great practical importance.

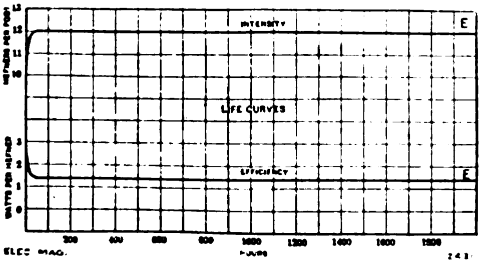


FIG. 7.

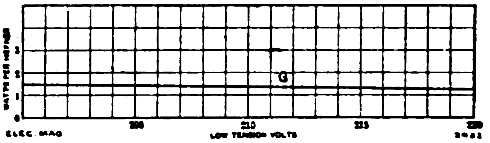


FIG. 8.

Curve *I*. The light intensity is nearly proportional to the watts.

Curve *J*. The light intensity is proportional to the tube amperes, and a tube radiating 13 hefners per foot of yellow light requires three-tenths of one ampere.

The degree of vacuum required in these tubes is about 0.10 of a millimeter, which, comparatively speaking, can be called a high vacuum. This vacuum is maintained within 0.01 of a millimeter or 0.00001 per cent. of an atmosphere either above or below the normal degree of vacuum. The solution of this very difficult problem of maintaining a degree of vacuum so nearly constant, was found by taking advantage of the fact that but slight changes in the vacuum cause enormous changes in the electrical resistance of the gaseous-conductor. For example, a tube 220ft. long at its lowest vacuum (0.11mm.), takes 24 amperes, but at the end of every minute this has crept up to 25 amperes, when a new supply of gas causes the amperes slowly to drop again to 24. Of course it is impossible to detect this slight oscillation either in the steadiness or intensity of the light in the tube. Making use of electricity to govern the vacuum is equivalent to using a multiplier of about 400,000.

These long tubes are built in place by

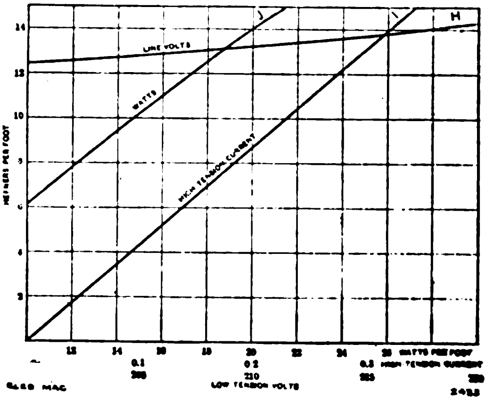


FIG. 9.

hermetically sealing together 8ft. 6in. lengths of 1.75in. glass tubing, with walls $\frac{1}{16}$in. thick, by means of a new blast illuminating gas—fire or double-flamed torch. This work can be done rapidly and cheaply, since in a 100ft. tube about a dozen joints are needed and only about two minutes are required for each one. This has necessitated the development of a new trade: namely, "glass plumbing."

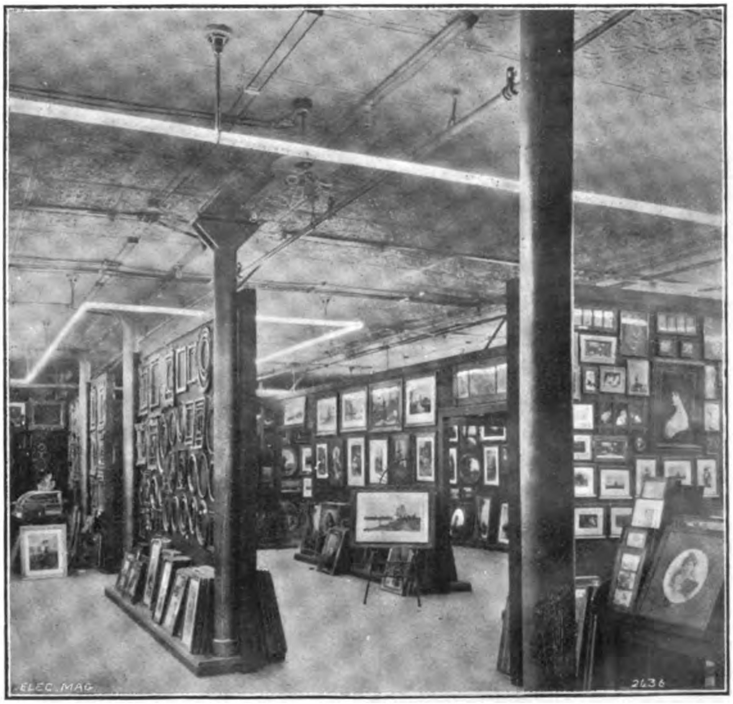
The two ends of the tube within the terminal box each contain a graphite cup electrode 8in. long. Immediately in front of one of these electrodes a branched small-bore tube extends to the bottom of the feed valve, see Fig. 1, and the other branch is available to be connected temporarily by a rubber hose to a new small portable oil vacuum-pump. The electricity is turned into the tube shortly after the pump is started and the amount of light resulting indicates in a measure the degree of vacuum in the tube. But in investigating a field of this nature a simple, rapid, and accurate vacuum-gauge was found to be very necessary, and it has proved to be as valuable an instrument as a compass is to a mariner. It can be calibrated to measure to one ten-millionth of an atmosphere.

As soon as the vacuum of the tube is sufficiently high, the feed-coil is adjusted to feed at proper intervals the right quantity of air or other gas. When the light automatically and continuously feeds itself from the atmosphere, the supply of which is of course inexhaustible, its life can be said to be indefinitely long. When it is desired to feed the tube on nitrogen only, the air is simply made first to pass through a small iron cylinder containing enough phosphorus to last several years. Should a longer life than this without any attention be desired, several cylinders can be used in series and these can be renewed an indefinite number of times at a negligible cost. Effectually to prevent more than is necessary of the atmosphere from coming into contact with the phosphorus, or being continuously in contact with it when the tube is not in use, it has first to pass through a small mercury trap.

To feed a tube with CO_2, a bottle containing a piece of marble and a little hydrochloric acid automatically generates this gas only when the tube requires feeding. Therefore this small gas generator needs only a new piece of marble at the end of several years.

Various portable or unit forms of this light have been designed. For example, one in which the tube is bent into a hexagonal form resembles somewhat an arc lamp. It operates at 220 volts and requires 25 per cent. less watts yet gives 25 per cent. more useful illumination than an enclosed arc.

The automatic feeding-valve is, of course, applicable not only to alternating-current vacuum tubes but also to direct-current



An Installation of the Moore Light in an American Picture Gallery.

vacuum tubes. It can be made invaluable for all kinds of vacuum-tube apparatus, such as X-ray tubes, vacuum oscillographs, wireless telegraphy or telephony, transmitters and receivers, vacuum or vapour rectifiers, or lamps.

The Moore Light at the Savoy Hotel.

For some time past there have been several installations of the Moore system of lighting in regular use in the United States; one of these is well illustrated on the preceding page, which is a general view of an art gallery, and exhibits to a marked degree the exceptional advantages which the new light possesses for this service.

In the early part of this month the first British installation was completed at the Savoy Hotel, London, the spacious courtyard being encircled with a Moore tube about 165ft. long. The effect is remarkably good and attracts great popular interest. In this case the rarefied nitrogen tube is used and the resulting light is of a warm yellow tone. The general details of the installation are as described in the above article. The air feed is drawn in by stages every few seconds by the automatic valve, passing first through a small mercury trap of the simple swan-neck type, then through a vessel containing phosphorus, where the oxygen is arrested; from this the nitrogen passes to the valve, and as required percolates in very small quantities through the graphite cone into the tube. At the Savoy Hotel, there being no public alternate-current supply available, a d.c.-a.c. motor-generator made by the Crypto Electrical Company was introduced. This set has a capacity of 5kw. at 220 volts and 50 periods. The actual current consumption of the Savoy light is 2500 watts at 200 volts on the low-tension primary side of the little transformer. This last, with the valve and air-oxidizing apparatus, forms the only auxiliary apparatus necessary for the light, and in this case it is conveniently placed overhead in an inconspicuous position.

So far as the actual erecting of the tube is concerned, which might at first sight appear a troublesome and delicate business, it is claimed that this is simplicity itself; the tubes, in lengths of 8ft. 6in. each, are of a special grade of glass, and they are butt-welded in position without difficulty by anyone having even a rudimentary knowledge of glass-blowing. At the Savoy Hotel the joints are so true that they are difficult to distinguish and the tube appears as a uniformly true continuous length.

Thanks are due to Mr. J. Livingstone, the representative of the Moore Electrical Company, Newark, N.Y., and who has carried out the work at the Savoy Hotel, for the very kindly interest he displayed in explaining the details of this pioneer British installation of a noteworthy lighting system which promises so well.

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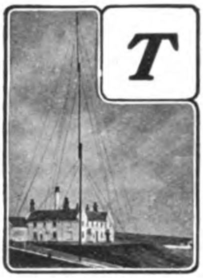
*Telephonic Transmission Measurements.**

B. S. COHEN AND G. M. SHEPHERD.

Continued from THE ELECTRICAL MAGAZINE, *May, page 336.*



THE results described in this paper have been obtained in the investigation laboratory of the National Telephone Company, and embody methods of measuring frequency, distortion, attenuation, current and power of telephone waves, and also line and instrument impedances.

Study of Wave-form and Distortion.—As might be expected, the oscillograph has afforded a great deal of useful information with regard to telephone waves.

The instrument used is the high-frequency pattern of Duddell. This instrument has two separate vibrators which can be used in a variety of ways. For investigating the attenuation and distortion of waves over telephone lines, one can be placed at the beginning, and the other at the end of the line.

Owing to the small resistance (about 10 ohms) of these vibrators and their negligible inductance, they have no appreciable disturbing effect on the circuit into which they are introduced.

This oscillograph is used in conjunction with the falling photographic plate arrangement. Owing to the high frequency and general complexity of many of the telephone waves, it is very necessary that the vibrators should be working at their correct damping temperature in order to obtain reliable records. As mentioned by Duddell and others, the best test for correct damping is a square wave produced by interrupting a direct current.

Fig. 1 shows a number of oscillograms of vowel sounds as interpreted by a common battery solid-back transmitter working at normal load. These were continuously sounded into the transmitter mouthpiece. These vowel sounds are quite characteristic, and can be picked out in many oscillograms of complete words, although they get altered somewhat in shape by different voices. The small ripple on the flat portion of the E wave marked y, for example, is considerably amplified in some voices, and the portion x very often disappears completely. The main characteristics, however, remain. E appears to be much the simplest of all the vowel sounds.

The falling-plate camera does not lend itself so readily to the recording of consonants, but by rapidly repeating the consonant and reducing the speed of the falling plate it is possible to obtain

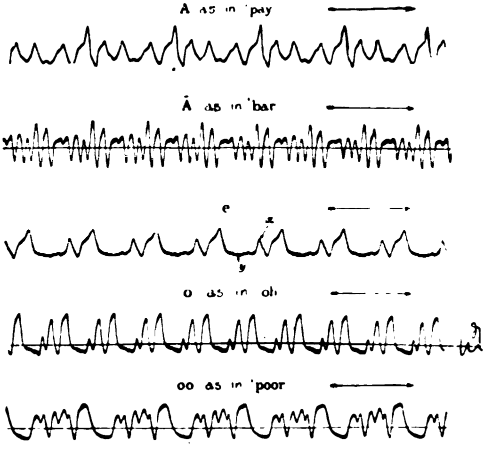


Fig. 1

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* Abstract of Paper read before The Institution of Electrical Engineers, London, May 9, 1907.

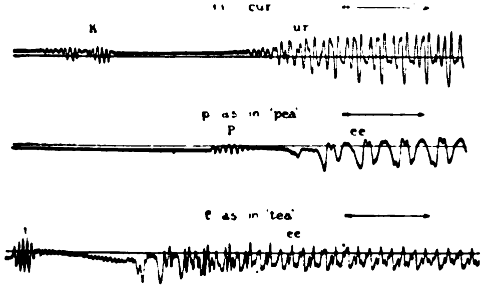


FIG. 2.

satisfactory records. Fig. 2 shows a number of consonants and words. The beginning and end of each word is indicated. These cases ("cur," "pea," and "tea"), which have all explosive consonants, are interesting. It will be seen that the explosive portion is quite separate and distinct from the vowel portion, being, in some cases, separated by an interval of quiescence. The question arose as to why the consonant portion in these cases should be generally of smaller amplitude than the vowel portion, as in the case of the originating sound wave the ear would appear to indicate that the reverse is the case. It was thought that this might be due to the transmitter diaphragm, which in the case of the solid back is somewhat heavy and is strongly damped, and would not, therefore, respond to the brief consonant portion so well as to the vowel portions. In order to prove this, the same consonants were recorded, using both the solid-back and a lighter diaphragm granular transmitter.

Fig. 3 shows the sound "tea" with the light diaphragm transmitter. In this case the consonant portion is nearly of the same amplitude as the vowel portion; the diaphragm is also very little damped, and indicates high frequency vibrations in the interval between the consonant and the vowel which were not shown up by the solid back. Fig. 3 also shows an oscillogram of the consonant portion of "tea" taken by itself. This is clearly a reproduction of part of the preceding figure, and helps to prove the accuracy of these oscillograms. It is interesting to note that the tests of the particular light diaphragm-transmitter used gave articulation superior to that of the solid back, although the former transmitter was in some ways inferior to the latter.

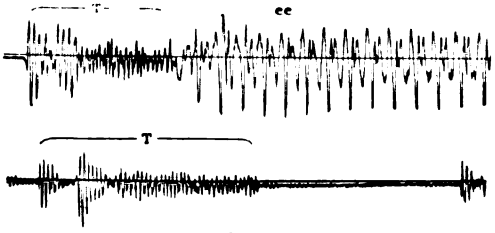


FIG. 3.

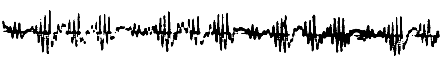


FIG. 4.

It may be of interest to mention that the most efficient sound from the point of view of amplitude is the "oo" vowel sound, as in poor; whilst the least efficient sounds are the consonants "s" and the rolled "r"; the "r," which is of very high frequency, is depicted in Fig. 4.

Change in Wave-form in Transmission.—The oscillograph is obviously specially suited to the investigation of the attenuation and distortion of waves over telephone lines, and particularly to the latter. Fig. 5 shows the attenuation and distortion of a fairly complex sound wave (singing "la") over a 16-mile cable line. The cable in this case was equivalent to one with 17.6 miles of 20lb. conductors, and the transmission over this length of line is very good indeed.

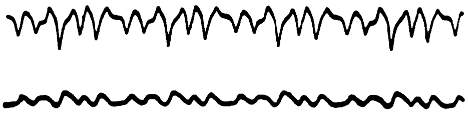


FIG. 5.

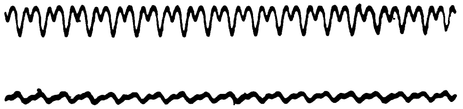


FIG. 6.

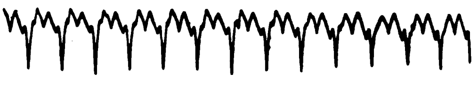


FIG. 7.

On analysing the received wave it is found that everything above the seventh harmonic seems to have practically been wiped out, and this harmonic represents a frequency of 980 ∿.

Fig. 6 shows a note sung by a girl in a high tone, which was taken as representing the upper limit for speech frequency. The line in this case was 16.6 miles of 20lb. On analysing these curves the highest frequency left prominent in the received wave was 3000 ∽. This is a very high figure, and does not necessarily represent a frequency that matters, firstly, because the fundamental was exceptionally high, and, secondly, because the speech limit is not reached until about 50 miles of 20lb. cable is in circuit; unfortunately we have not found it possible to obtain an analysable record over this mileage with the oscillograph.

The analysis of the two waves in Fig. 5 brings to light the fact that the attenuation of the current behaves in a curiously fluctuating manner as the frequency increases. The following table gives percentages of received currents for the various harmonics :—

Harmonic.	Percentage received.	Harmonic.	Percentage received.
1 (Fundamental)	81.0	9	25.0
2	47.0	10	25.0
3	57.0	11	81.0
4	46.0	12	13.0
5	41.5	13	2.5
6	28.0	14	15.5
7	25.0	15	4.0
8	30.0		

The big rise at the eleventh harmonic is very noticeable.

A further example of this effect is apparent in the wave-forms of Fig. 7, which represent a singing "oo" sound on 30 miles of cable. Analysis up to the eleventh harmonic shows the following percentages received :—

Harmonic.	Percentage received.	Harmonic.	Percentage received.
1	34.3	7	6.3
2	16.7	8	1.5
3	6.0	9	33.0
4	5.0	10	16.4
5	1.0	11	8.2
6	7.3		

The ninth harmonic is the notable one in this case, and would have a frequency of about 2295 ∽. Such analyses as the above are, of course, somewhat rough affairs, owing to the difficulty in obtaining clearly defined enlargements of attenuated wave negatives; it is also an extremely laborious business.

The absence, unfortunately, of any precise data regarding the terminal conditions of the circuit when these oscillograms were taken, renders it impossible to explain the phenomena theoretically. That such an occurrence is in some degree possible, however, may be demonstrated by taking an arbitrary complex e.m.f., and supposing this to be impressed upon a circuit of known electrical constants. Thus, let the following:

$$E = 100 \sin pt + 75 \sin (2\,pt - 45) + 50 \sin (5\,pt + 30),$$

with a fundamental of 200 ∽, be the actual potential difference at the sending end of a cable line whose data are: length, 15 miles; capacity, 0.054m.f. per mile; resistance, 85 ohms per mile; inductance, 0; and which is terminated by a piece of apparatus, such as a telephone instrument of, say, 0.18 henry and 200 ohms.

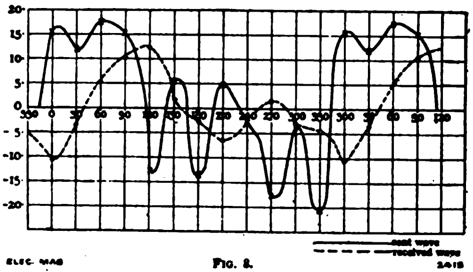
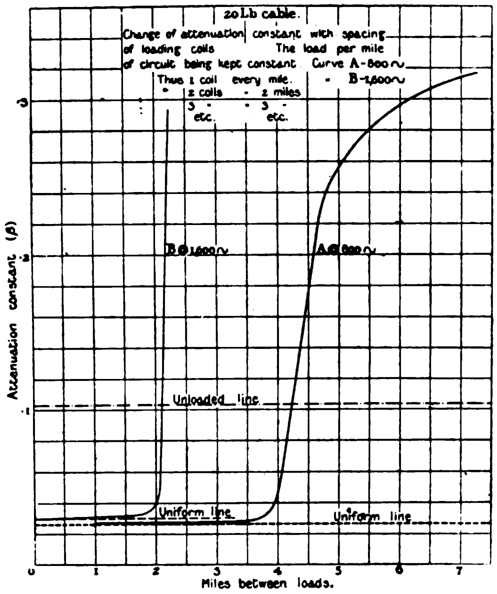


FIG. 8.

Fig. 8 shows the above function plotted out through a complete period, both for the beginning and end of the circuit. In this theoretical example the percentages of received current for the three harmonics present are respectively:

1st	57.4 per cent.
2nd	71.5 „
5th	14.4 „

Oliver Heaviside deals with this matter at some length in his collected papers, Vol. II., and shows, by means of the equation for the receiving end impedance, that the latter passes through successive maxima and minima values with increasing frequency. These fluctuations become less and less marked, and finally disappear at high frequencies. What precisely the practical effect on transmission is of this special reinforcement and diminution of certain tones we cannot at present say. The causes tending towards distortion are so many and varied that perhaps the resultant effect is not so strongly felt as might otherwise be the case. At all events, Heaviside's remarks regarding the instinctive quality of the human ear for recognising what must in reality be the merest phantoms of speech vibrations, appear to be pretty well borne out in practice. Volume is the prime necessity; articulation is, comparatively speaking, of



ELEC MAG FIG. 9. 2416

secondary importance. The subject of line resonance (if that term may be applied) seems, however, to be one worthy of closer investigation.

As previously mentioned, figures for the highest frequency met with in speech waves, which must be retained in order to obtain intelligible speech are of great importance, and, although the oscillograph may help to obtain some idea on this subject, this method is necessarily exceedingly complex and laborious, and involves the likelihood of considerable error, although it must be borne in mind that any absolute figures are out of the question, as the point at which articulation becomes so bad as to render the speech unintelligible involves the personal equation to a considerable extent.

Highest Important Frequency in Telephone Waves.—Some tests carried out on loaded lines led to an interesting method of ascertaining the highest important frequency in articulate speech. If the spacing—*i.e.*, distance apart—of loading coils is increased, and at the same time the amount of inductance per mile inserted is unchanged, the attenuation constant also increases gradually, and at one particular spacing increases to an enormous extent. Fig. 9 shows curves for the variation of attenuation constant with spacing for frequencies of 800 and 1600 ∽. These curves were calculated from formulæ by G. A. Campbell, and have been confirmed by tests made with a sine-wave alternator.

As the articulation of a received telephone wave depends to a very great extent on the attenuation of the harmonics present, it was thought that the application of the arrangement just referred to would help to settle the question as to which frequencies determine by their presence or absence the difference between articulate and inarticulate transmission. A series of articulation observations were consequently made on 20 miles of cable for increasing spacing intervals with a constant load of 0.17 henry per circuit mile and commencing with a distribution of 1 load per mile.

It was found that a two-mile load was very slightly inferior to the unloaded line of equivalent speaking volume, but still gave excellent commercial transmission. This indicates that harmonics above 1600 ∽ may be dispensed with (see Fig. 9).

With three-mile distribution the articulation was commercial, but decidedly inferior to the unloaded line. The critical frequency for this disposition of the load was about 1100 ∽, and it is thus apparent that harmonics between 1100 ∽ and 1600 ∽ are valuable.

For four-mile intervals speech became

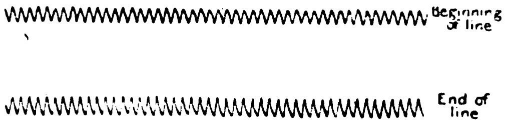
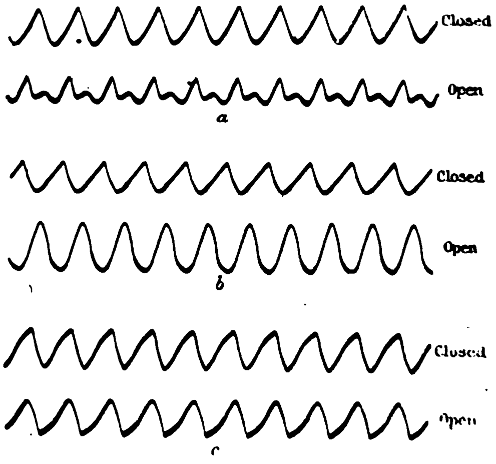


FIG. 10.



ELEC MAG FIG. 11. 2417

quite impossible, although the volume was still quite considerable, and we must therefore conclude that the highest indispensable frequency lies between 800 and 1100 ∽, and also that it is desirable to retain something higher than 1100 ∽ for really high-grade transmission. Probably 1500 ∽ would be quite a satisfactory figure to base calculations on.

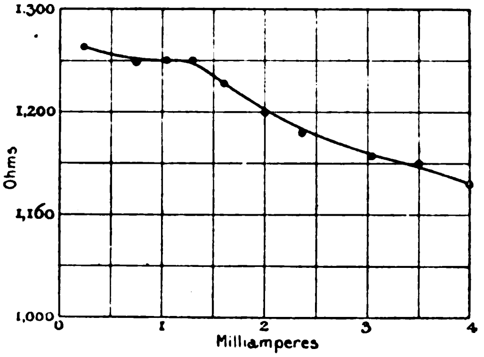
Pupin and other writers use 750 to 800 ∽ for many transmission calculations. It is important to note that this represents a fair average frequency, as damping constants calculated with this value can be obtained experimentally when using actual speech waves.

Relationship between Sent and Received Waves on Short Cable Lines.—On short cable lines and provided that some amount of terminal impedance exists at both ends of the line, the relationship between the sent and received currents is somewhat peculiar. Fig. 10 shows the wave at the beginning and end of a line equivalent to 2.2 miles of 20lb. cable, and in this case the receiving end wave is of considerably greater amplitude than the wave at the transmitting end.

The wave in this case was produced by whistling into the transmitter. The effect is considered further on in connection with telephone current measurements.

Fig. 11a shows the effect on the transmitted wave when opening and closing the receiving end of a line consisting of two miles of 20lb. cable. With this short line the cable current passing from the A to the B wires, by virtue of their mutual capacity, is smaller than the total current flowing when the far end is closed. The variation in wave-form is also very noticeable. When, however, the line is 7.5 miles of the same cable, the current is actually greater when the far end is open than when it is closed (see Fig. 11b). Lastly, when the line gets beyond a certain length, the effect on the amplitude at the transmitting end by opening and closing the receiving end is negligible. Fig. 11c shows the effect with twenty miles of 20lb. cable.

These phenomena, which are dealt with further in another part of this paper, are due to the action of the terminal impedance, and may prove of considerable importance to the telephone engineer, as they can be varied to a great extent by varying the impedances of the terminal apparatus. With long lines, the tendency is for the impedance at the sending end to become a constant quantity, not varying appreciably with the length, and the reaction of the terminal apparatus becomes evident only to a very small degree at the sending end.

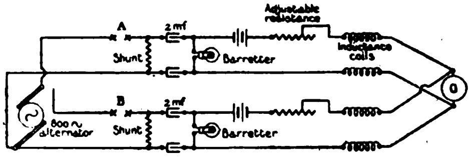


ELEC MAG FIG. 12. 2418

Current Measurers and Measurements.—Two forms of apparatus have been used, the barretter and the thermo-galvanometer.

The barretter, otherwise termed the bolometer, is a device for measuring small alternating or fluctuating currents. It consists of a conducting wire or filament, which has a high temperature coefficient and a small mass, so that small currents will appreciably raise the temperature, and thus alter the resistance. The barretter has been employed by Professor V. Boys in constructing the radio micrometer; by Fessenden; by Lieutenant Tissot for wireless telegraph measurements (see *Journal of I.E.E.*, April, 1906); and, lastly, by Professor Kennelly (see *Transactions* of International Electric Congress, St. Louis, 1904).

Professor Kennelly used barretters made of very fine platinum wires. Owing to the extreme delicacy of these wires, Dr. Hayes, of the American Telegraph and Telephone Company, carried out investigations to discover a barretter more suitable for work outside the laboratory. He found that small low-voltage telephone switchboard lamps gave satisfactory results, and this has been confirmed by experiments carried out by the authors. The best lamp they have found for this purpose is a special pattern 24-volt curl filament lamp for telephone switchboard use. The curve (Fig. 12) shows the relationship between the current and the resistance using this lamp. Following the usual law, the greatest resistance variation with these carbon filaments occurs when using small currents.



ELEC MAG FIG. 13. 2419.

Experiments have been tried to increase the sensibility of the filaments by overrunning the lamp for some hours, and thus reducing the mass; but although great sensibilities have been obtained, it was found impossible to make a number of barretters exactly similar to one another. The filaments always reduce at their weakest point, and, in consequence, although two filaments could be obtained having the same sensibility, the time of response to a change of current varied, and with the null method of working barretters described further on, this gave rise to trouble.

Null Method of Working.—The arrangement of barretters, shown in Fig. 13, has been adopted after considerable experiment. This enables measurements of apparatus and line impedance, capacity, &c., to be carried out, the result being obtained in actual ohm values, and with very little more trouble than that involved in taking an ordinary resistance measurement with direct current.

The figure shows a source of alternating current such as a sine-wave alternator connected to two branch circuits, in one of which a variable resistance box A is inserted. The other arm has the apparatus or line to be measured, inserted at B. The barretters are connected through adjustable resistances and batteries to the galvanometer, which can be of any pattern. The shunt, which for general work can be varied from 10 to about 500 ohms, helps to eliminate errors due to the impedance of the barretter circuits.

The barretters are first balanced in resistance by the adjustable resistances until the galvanometer indicates no deflection. The alternating current is then applied, the circuit being through the condensers and round the barretters. This current is stopped from passing from one branch into the other, *viâ* the galvanometer, by the four choking coils. When the resistance box in A is adjusted so that no deflection is indicated on the galvanometer, then the resistance unplugged in A, after making allowance for the impedance of the shunted barretter circuits, represents the impedance of B, and if the two barretters are not exactly similar, a second reading can be taken with A and B reversed and the mean taken. Variations in barretter resistance caused by temperature changes have no effect on this arrangement, as the barretters are fixed close together and compensate each other.

Corrections to be Applied when Measuring Effective Resistance Inductance, or Capacity, by the Barretter.—*Inductance.*—Let R be the balancing resistance unplugged from the box, and r the total resistance of barretter and shunt, and R_0 the effective resistance of the apparatus measured (includes true resistance and iron losses).

Then—

$$I^2 = R^2 + 2r(R - R_0),$$

provided that the impedance of circuit on galvanometer side of barretter is high enough to be negligible, and that both circuits are fed with the same voltage.

From the equation it is evident—

(1) If r is small enough, R is the true impedance. In no other case is this so.

(2) In some cases R_0 will be small compared with the reactance, and then—

$$I^2 = R^2 + 2rR.$$

(3) By varying r and taking (two) readings it is possible to eliminate I and obtain R_0. Thence the impedance and inductance can be obtained.

By taking $x r_1 = r_2$, then—

$$R_0 = \frac{R_2^2 - R_1^2 + 2r_1(xR_2 - R_1)}{2r_1(x - 1)}.$$

Condenser Measurement.—In this case the same formula will hold, R_0 being the effective insulation of the condenser. It includes dielectric losses. As a rule these are negligible, and we get—

$$I^2 = \left(\frac{1}{cp}\right)^2 = R^2 + 2rR.$$

Deflectional Use.—In this method only one barretter is actually used, the other being merely left in the circuit to balance the one used, both for atmospheric temperature variations and for resistance. One of the barretters is inserted in the circuit in which the value of the current strength is required, and the change in its resistance due to this current causes the galvanometer to deflect. The instrument then becomes practically a hot wire ammeter. It has this disadvantage that it is somewhat difficult to

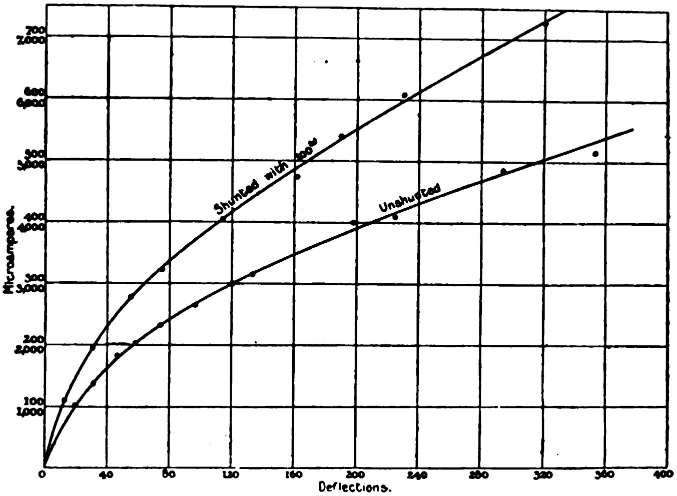


FIG. 14.

calibrate. The simplest method of calibrating is to pass an alternating current through the barretter in series with a known variable resistance, and measuring the p.d. across the latter with an electrostatic voltmeter. Fig. 14 shows such a calibration curve. It will be seen that 60 micro-amps. correspond with 10 divs. deflection (about 5 mm.). This is about the minimum measurable.

The sensibility of the barretters used in relation to telephone currents is such that fairly small non-inductive shunts can be used to eliminate the effect of the barretter impedance.

When testing telephone lines, ordinary telephone repeating coils, &c., can be inserted in order to give the ordinary terminal conditions met with in practice.

Thermo-galvanometer.—Duddell's thermo-galvanometer has been used for current measurements. It has many advantages, and for deflectional methods is probably unrivalled if the source of power is absolutely steady, but it cannot be satisfactorily employed with transmitters in circuit owing to their variability, even although the sound impressed is quite steady. The barretter is somewhat better for this purpose, as the mass of the filaments employed is greater than that of the heaters used in the thermo-galvanometer of the same relative sensibility, and consequently the time of response to a current variation in the thermo-galvanometer is smaller, and the sensibility to momentary disturbances thus much greater. This comparison, of course, only refers to the actual apparatus employed, and it should be quite possible to alter the time of response of the thermo-galvanometer, and thus reduce its sensibility to small disturbances. Some of the measurements referred to hereafter have been made with the thermo-galvanometer.

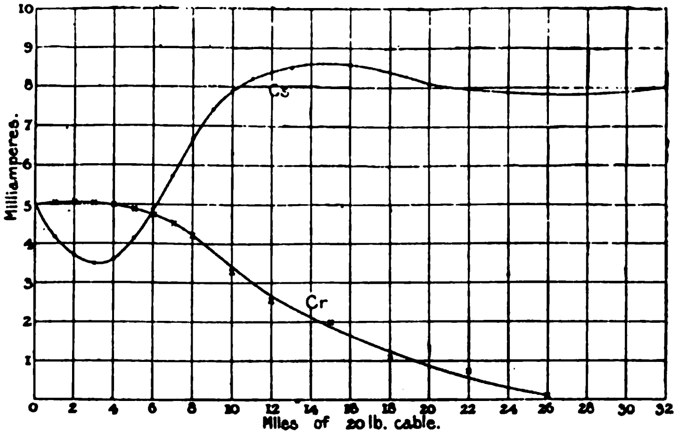


FIG. 15.

Current Measurements. — The relationship between the currents Cs and Cr at the beginning and end respectively of different lengths of telephone line can be readily measured with two barretters. As mentioned before, the relationship is complicated by the addition of terminal impedances at either end of the line. Fig. 15 shows this current relation plotted for various lengths of 20lb. conductor cable equipped with ordinary telephone instruments at either end.

It will be seen that up to nearly six miles the received current is greater than the sending current. At about twenty miles the sending end current, which has up to this

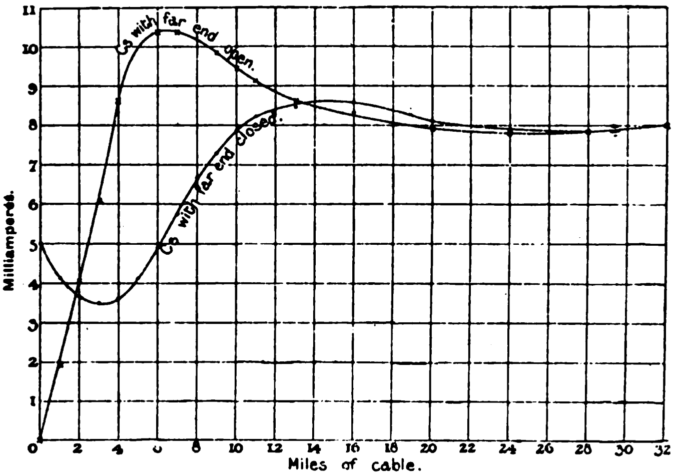


FIG. 16.

length been mostly increasing, has practically reached a constant figure, and is after this very little affected by any further increase in the length of line. The necessity for allowing for the action of the terminal apparatus is well emphasized by these curves.

Fig. 16 shows the relationship between the current at the sending end of the line when the receiving end is open and closed for various lengths of line. The cable line used in this case had 20lb. conductors, and the line was terminated as before at either end by ordinary telephone instruments. It will be noticed that at about twenty miles and upwards the current flowing into the cable is practically unaffected by the opening and closing of the receiving end, and that this also happens at about two miles. The current used for the above tests was at 800 ∽, and practically sinusoidal in form.

Determination of Damping Constants on 20lb. Cable.—This was done by actuating an ordinary telephone transmitting circuit by a steady musical note and then observing the ratio of sending and receiving currents on a varying length of cable, which could either be shorted at the far end or closed through a known impedance. The appended table shows the relation found between the actual Cs/Cr, and the hyperbolic function cosh (la), which is the calculated ratio of Cs to Cr. (Where *l* is the length of line and *a* the complex attentuation constant.)

Considering the irregularity in wave-form of a microphone produced current, the agreement between theory and practice is very fair. The telephone currents actually used were of the order of those commonly observed on standard common battery junction circuits.

By roughly balancing up a treble C singing note sung into a transmitter against a sinusoidal alternating current of similar frequency placed direct on the junction at the transmitting end, and then measuring the latter current on the thermo-galvanometer, a general idea of the magnitude of the talking current is obtained.

Miles.	$\frac{Cs}{Cr}$	∽	Cosh (la)	Error
		Far end sho	rt-circuited.	
5	1.065	792	1.0287	—3.5 %
10	1.385	783	1.3740	—0.8 %
15	2.310	763	2.3100	0.0 %
	Far end clo	sed through	impedance	22 ohms 0.15 henry
10	1.302	792	1.2400*	—4.8 %

* This figure is the ratio of receiving end to sending end impedance.

At the sending end of the line and at the junction side of the repeating coil a current of about 5m.a. and a p.d. of about 3.5 volts was observed. In the receiving instrument secondary, about 2.4m.a. with ten miles, 0.53 m.a. with thirty miles, and 0.24m.a. with forty miles of 20lb. cable were measured. There were local subscribers' loops of 150 ohms resistance in connection with the above circuit.

(*To be continued.*)

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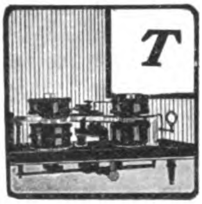
A Practical Limitation of Resistance Furnaces; The "Pinch" Phenomenon.

CARL HERING.



THE object of the present paper is to describe a limiting condition sometimes encountered in practice with resistance electric furnaces, which appears not to have been known, and was very unexpected, and which may at times be serious and perhaps quite insurmountable. It applies to that type of resistance furnace in which the material to be treated forms the resister, in the form of a column of liquid in a trough, as distinguished from that type in which the resister is a foreign body, which is surrounded or enclosed by the materials to be treated.

As the reason for using an electrical furnace instead of a combustion furnace is generally the high temperature it produces, the conditions encountered in practice which limit the temperature may become very important. In the present paper the term limitation will therefore be used to refer to those conditions which limit the temperature.

It might be argued that by simply increasing the watts per cubic inch in a furnace, any desired high temperature may be reached, up to that of volatilization, which means the destruction, of the resister.

This, however, is not the case. A limit may be reached which is far below this temperature, due to a curious and surprising phenomenon, which the writer has observed and which he has termed the "pinch phenomenon." This limit may at times be a very serious one, as it is sure to exist, and may sometimes limit the temperature to such a low value as to entirely defeat the object of the furnace. This phenomenon has apparently never been mentioned or described in the leading treatises, and, therefore, does not seem to be generally known, and, as it may at times be a very serious limitation to the possible temperature in some electric furnaces of this class, a description of its effects will be of interest to furnace designers. Theoretically, this curious phenomenon is also of considerable interest. Dr. E. F. Northrup, of Philadelphia, to whom the author described this phenomenon some months ago, took a great interest in it, and made a very thorough and able study of it, both from the mathematical and physical, as also from the experimental standpoint, including also the quantitative relations. His very interesting paper was read before the Physical Society (U.S.A.) on March 2.

The phenomenon is as follows: When the current density in a liquid conductor in an open channel is increased sufficiently, the conductor will be found to contract in cross-section with considerable force, especially at a place where there is some slight obstruction in the channel, or where, for any other reason, the cross-section is less than the average. This contraction resembles the depression in plastic material that has been pinched between the fingers; as the column of liquid looks as though it were being pinched by some mysterious and invisible force, the writer termed it the "pinch phenomenon," for want of a better name.

In the diagram *E E* are the cold electrodes of such a furnace; *C* is the column

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[*] Abstract of paper read before the American Electrochemical Society, Philadelphia, May 2, 1907.

of liquid conductor, which acts as the resistor, and *P* is one of these pinched contractions. The liquid on both sides of the contraction slopes like the letter V, with inclinations of 45deg. and over. The liquid will stay in this position, thus forming a stable state. The inclined surfaces of the liquid, though smooth, showed signs of great internal agitation, as though the liquid was continually running downhill, but was being as rapidly forced uphill again. It was a somewhat curious and interesting sight to see the surface of a liquid sloping at a steep angle and yet be in a stable state. The first impression was that a large leak had suddenly formed, and that the molten metal was rapidly flowing down and out through it; but it was soon found that the condition was a stable one.

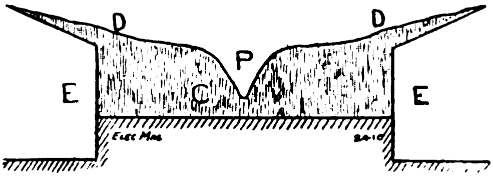


Diagram showing "Pinch" Phenomenon.

When, under these circumstances, the current density is still further increased, this V-shaped depression becomes deeper and deeper until it finally reaches the bottom of the channel; this, of course, breaks the circuit and the liquids then immediately flow together, only to be instantly parted again, thus forming a violent automatic interrupter of the current, accompanied by a sputtering of the metal, loud crackling sounds, and, incidentally, by the great disgust of the man who is running the furnace, as it means that the limit has been exceeded, and if the circuit is not opened at once at the switch, to allow the parted liquids to flow together again to their normal level, there is a strong likelihood that the reduction of the current will cause the core to freeze in this parted condition, which gives rise to serious difficulties in mending the break so that it will carry current again.

If there is any dirt, infusible material or pasty, poorly-conducting slag floating on the surface of the liquid, it will naturally fall into this cavity, and as the conductor in the narrow neck is apt to volatilize, owing to the high current density, while the rest of it is apt to freeze, owing to the reduction of the current, the result is that a complete break is apt to form, through which it may be very difficult and sometimes impossible to start the current again, thus requiring a dismantling and reconstruction of the furnace. It is obvious that this phenomenon places a limit to the current, which can be passed through a liquid resister of given cross-section, thereby limiting the temperature which can be obtained. This limit may be far below that desired, thus completely defeating the purpose of the furnace. It is, therefore, an important factor to be taken into consideration by the designers of this class of furnace. What the limit of temperature will be, will depend, of course, on the particular circumstances; it is evidently not possible to give any fixed rule. It may, perhaps, be subject to calculation, but this is doubtful, as this local pinching seems to be originally induced by some obstacle or contraction in the channel, which, being generally accidental, is not within the reach of mathematics.

It is certain, however, that this tendency to pinching, and consequent parting, exists and must be guarded against. If, for instance, a portion of the channel is made smaller than the rest, for the purpose of increasing the temperature locally, great danger exists that this phenomenon will defeat that purpose, and it should first be determined by experiment, whether it will take place, before dependence is placed on the operation of such a design. Under some conditions this temperature limit will be quite low; with mercury, for instance, this pinch phenomenon will take place under favourable conditions before the temperature has risen appreciably.

One of the experiments made by Dr. Northrup, at the writer's suggestion, has shown that if the channel is quite uniform, the contraction in cross-section will also be uniform over its whole length—that is, the level of the liquid will lower uniformly, and, therefore, the danger of parting will not be so great. This explains the observation made by the writer that in a furnace of this type the liquid conductor kept creeping up on top of the cold electrodes, as at *D D* in the illustration, piling itself up in large quantities, and solidifying after it got there. Fresh material had to be added for some time to keep up the level, until the stable conditions were finally reached. This stable condition is different for each current.

The question naturally arises, how can this pinch phenomenon be avoided. As the forces which cause it, namely, radial pressures toward the central axis, are bound to exist, the only way seems to be to render them as harmless as possible, instead of trying to resist them. To do this, the channel should be made as perfectly uniform as possible and kept free from obstructions. A very liquid flux should be used, if possible, to dissolve any solid foreign particles and to float or wash them away. The cold electrodes should have vertical faces where they are in contact with the liquid resister, so as to obstruct as much as possible the piling up of the liquid conductor at those places. When the current is stopped, the level of the liquid will become horizontal again, and will therefore rise, hence an additional range of regulation must be provided for starting up again with an enlarged cross-section. But, even with all these precautions, an increase of current density will lower the level until at some weak point a rupture will be likely to take place.

Another precaution is to make the channel as deep as possible, and, therefore, narrow in width. The writer noticed, and Dr. Northrup has since confirmed it by experiment, that the force which causes this pinching does not act to produce an unstable equilibrium; the contracting force reaches a stable state when it is balanced by the hydrostatic pressure of the liquid. Hence, by making the channel deep, the tendency to a complete break is reduced. This, however, necessitates making the channel narrow, thereby increasing greatly the tendency to develop a weak spot due to some obstruction or contraction. It also greatly increases the loss of heat through the walls of the furnace. Hence, both depth and width should be made large, which means short channels, low voltages, enormous currents, or else a large capacity of the furnace. In other words, the danger from this source is greatly increased as the furnace becomes smaller in capacity. Some idea of the strength of this contracting force may be had from a case in the writer's experience, in which the V-shaped depression extended down as much as 6in. through molten iron to the bottom of the channel, causing a complete rupture, followed by freezing, which necessitated the dismantling of the furnace.

Another good rule is, do not use liquid resistors if the conditions permit using a solid one, which heats the materials by contact. There are other reasons also for this conclusion.

Those interested in this phenomenon from a physical standpoint are referred to Dr. Northrup's paper, mentioned above. He therein demonstrates, mathematically, the correctness of the writer's first assertion, namely, that the contracting force was due to the encircling lines of force, and that its effect was, in some, though not in all respects, like that of stretched elastic bands, tending to compress the conductor radially toward the centre. He furthermore found that this compression produced a pressure at the centre, causing the material there to be forced out at both ends along the central axis, somewhat like when a rubber tube, filled with liquid, is squeezed or pinched with the hand, which will tend to force the liquid out at both ends. With a vertical column of mercury, he has succeeded in thus producing a small fountain of mercury issuing from the centre of a large conductor, and by letting this mercury flow back near the outside of the conductor, the fountain plays continuously; thus he produced continuous motion by merely passing a current through one conductor, without magnets, commutators, brushes, bearings, &c., presumably the first time such motion was ever produced. As was originally observed by the writer, the phenomenon is independent of the direction of the current, and hence takes place with either direct or alternating currents.

The action might be explained, as Dr. Northrup suggested, according to the principle that currents flowing in a like direction attract each other. Hence, all the linear current elements in a conductor should be attracted to its centre, causing a contraction. This does not, however, explain why these current elements should drag the material of the conductor with them; why does not the current simply become denser at the centre? An electrical current passing across a running stream does not seem to be carried down with the stream as though it were inseparable from the water; but it always seems to take the shorter path across it; then why should the electric current, when in motion, drag the conductor with it as though it were inseparable from it? Yet it does do so in some cases, as in a uni-polar disc motor, and one is therefore led to conclude that this matter has not yet been clearly explained by physicists.

The writer's belief is that his original suggested explanation is more satisfactory, namely, that this pinch phenomenon is due to some action of the ever-present encircling magnetic lines of force, which are all under tension like stretched rubber bands, and therefore exert a radial pressure on the material which carries the current. Dr. Northrup's mathematical investigations confirm this suggested explanation, in so far that he has shown that the contracted conductor has many more lines of force encircling it on the outside than the original had, when both carry the same current; he shows that many additional lines of force are created by this contraction, and their radial pressures, due to their tension, have therefore been added to that of the others, which were there before; this would explain the increased pressure on the contracted conductor.

Although this phenomenon is a serious obstacle in electric furnaces having liquid resisters, it at once suggested to Dr. Northrup an application to simple forms of measuring instruments like those of the indicating and integrating types, that measure direct and alternating currents equally well, and it may raise in the mind of the inventor new visions of the possibilities of the long-looked-for commutatorless direct-current dynamo and motor, or self-starting single-phase alternating-current motor.

An analysis of this phenomenon leads to many interesting deductions. One of these is that Ohm's law may perhaps not be strictly true for high-current densities. Another is that the action of fuses and of the Caldwell interrupter may be due, in part, at least, to this phenomenon. Perhaps the action of the speaking arc is also due to it.

This phenomenon should be clearly distinguished from the well-known and entirely different one, according to which a flexible circuit tends to enclose the largest possible area. The latter has been observed in induction furnaces, in which the molten iron in the circular trough sometimes acts as though it were under strong centrifugal influence.

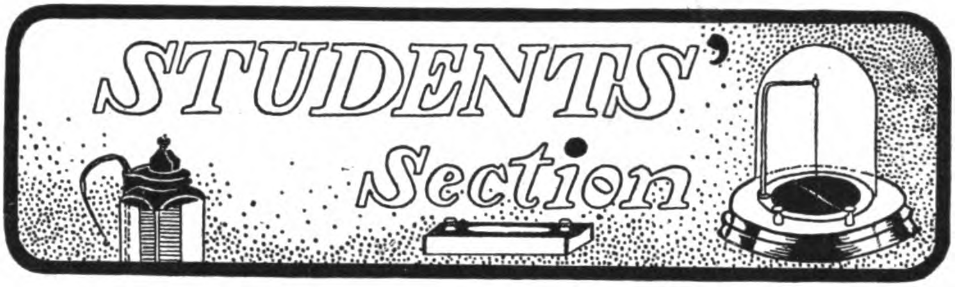
Electrolytic Caseine.

In a new process invented by Mr. Gateau, of Paris, caseine, instead of being formed as usual by treating milk with different substances for curdling it, is produced in an electrolytic bath. The essential features of the process are as follows:

In the centre of a tank filled with skimmed milk heated to about 80deg. C. is placed a porous vessel containing a solution of caustic soda, about five per cent. strength, in which is dipped an iron cathode. The anode is made of carbon and placed in the milk with about 4in. distance between the two electrodes. When a current having a density on the anode plate adjusted at 0.01amp. per square centimetre of surface is passed it is found that phosphoric acid is set free in the milk and this causes the caseine to be precipitated. With a current of 160amp. and a voltage of 11 volts the apparatus will take all the caseine from 100 litres of skimmed milk within twenty minutes.

In place of an alkaline solution the whey coming from a preceding process can be used in the porous cup, this being kept at the same degree of concentration which it has after the precipitation of the caseine. The electrodes are disposed as before, and it is possible to precipitate within ten minutes all the caseine from 100 litres of milk by passing a current of 160amp., and 18 volts.

Another variation of the process consists in surrounding the anode by a porous vessel so as to collect the phosphates and phosphorous acid as by-products, or again, if this arrangement is not used, the current may be allowed to pass after all the caseine has been precipitated so as to have a greater proportion of phosphoric acid. The new process has several apparent advantages. In the first place it gives a better yield of caseine than the usual methods, and again the expense for current is less than for the products used generally for curdling the milk, at least in cases where cheap current can be had from a hydraulic plant or a windmill. As it does not introduce any foreign products into the milk, it is better adapted for giving food products. The method is well adapted for giving the caseine which is used in the compressed product known as galalith, which forms a hard block, and can be turned in the lathe. It is used for various purposes in manufacture, and can often replace celluloid to advantage.



Students should refer to the World's Electrical Literature Section for classified list of articles of special interest to them.

Engineering Course of the Westinghouse Electric and Manufacturing Company, U.S.A.

H. D. SHUTE.

In the early days when the Company was comparatively small, they began in a somewhat unsystematic manner to take each year a few of the graduates from the leading technical schools. At that time no regular plan was followed in the treatment of these young men. In almost every case each man was selected to do some particular engineering work, and almost immediately upon his arrival took a definite and fixed position in the Company's engineering or works organisation. About 1890 a definite plan was put in force by which about thirty or forty engineer graduates were each year taken into the works. These men were not selected for any particular ultimate position, but were chosen for their general average ability, it being the Company's purpose that they would be developed in the manufacturing and testing departments for ultimate positions with the Company, such positions depending upon the ability and temperament which the men displayed during their period of preliminary shop training. No definite length of time for this so-called "Student's Course" was arranged. The men were placed nominally under the charge of the chief of the testing department. They were not, however, immediately placed in the testing room, but as they reported for work were placed in the various works departments, where they wound armatures, assembled transformers, chipped castings, and did other similar work. As they developed, and as the need came, they were transferred to the inspection and testing departments, and finally through a somewhat haphazard scheme, according to the general rule of the survival of the fittest, were promoted to positions involving more specific engineering work. This plan, it will be noted, was more or less hit or miss.

Under this system the high-calibre men quickly shone forth, were recognized, and given positions equal to their ability. The general run of the students, however, did not receive that supervision and careful training which would lead to the greatest good in the way of development for the greatest number.

As business grew, the needs for designers, general engineers, expert technical salesmen, commercial office men and superintendents largely increased until about 1900 it became evident that a definite course for engineering students was necessary to the development and growth of the organization.

In making a decision as to the proper engineering apprenticeship course to instal, the following alternative plans were available:

1. That the entering technical graduates should be taken directly into the engineering, construction, or commercial departments without being put through a course in the shops.

2. That these young engineers should be taken directly into the various testing departments without being given any preliminary manufacturing work, and that their whole development should be obtained by means

of the transformer, detail, motor or dynamo testing work.

3. That these young men should be first placed in the manufacturing departments, where they would receive definite and direct experience in manufacture, such work to be supplemented by a course in the various testing departments.

4. That these men should be given a course in the manufacturing departments, followed by a course in the testing departments, to be finally supplemented by a course either in the engineering, the commercial, or the outside construction department.

The decision was in favour of this fourth plan, and was reached principally by a consideration of the question as to the class of men that was needed, and by observation of the results secured by the methods previously employed.

Men were, and are still, required to deal with designing problems; to erect and operate apparatus in customers' plants; and to act as technically trained salesmen and commercial office men. Men to fill such positions should have a knowledge of the way electrical machinery is made, should get in close touch with workmen and skilled mechanics in order that at a later time they may know how to direct such men. They should also know, through the actual testing of the apparatus, what the various appliances will do in practice.

The school period of the engineer is planned for the acquisition of fundamental principles upon which to build the foundation upon which his later engineering career shall rest. The course at these works has been planned with the idea of building upon the foundation gained at the technical school the first story of such an engineering career.

The course as devised and as at present in practice is nominally of two years' duration. The average graduate of a technical school should take that much time in his general development before choosing finally his particular engineering career. In the majority of cases at this present extremely busy period, very few of the young engineers have the advantage of remaining on the course for the whole two years, but before that time are given permanent positions with the Company or find satisfactory positions with outside manufacturing or engineering concerns.

Upon entering the works, the young man is placed in one of the minor manufacturing departments and is put to winding coils or assembling brush holders or other details of manufacture. At regular and frequent intervals he is transferred from one department to another of the manufacturing sections, before entering assembling departments, where he obtains practice in the building of generators, motors, rotary converters, and transformers.

The value of the training obtained during this works period is by no means confined to the knowledge obtained of the details of the manufacture of the apparatus, nor to the practice obtained in the handling of tools. The principal benefit derived from this part of the course is due to the fact that during these months the young engineer comes in actual contact with labour. All engineers, if they expect to achieve prominence in their profession, must sooner or later be called upon to deal with problems arising from the relations between employers and labour. Every engineer probably hopes sooner or later to be an employer. When that time comes the young man will find that the direct knowledge gained of the way skilled and unskilled workmen think will be of inestimable value to him.

Having passed through the shop portion of his course, the engineer is transferred systematically through the various testing departments, where he is given an opportunity to test high-tension transformers, detail apparatus, such as switches, circuit-breakers, controllers, and wattmeters, and is finally placed in the dynamo and motor testing department. At another period he is transferred, as a part of his course, to either the engineering, commercial, or construction departments. If, after trial in such department, it is found that his qualifications are such as to make him a valuable man in that particular department, and if he feels that the work therein is of such a nature that he will make a success of it, he is given a permanent position and an opportunity to further advance and develop.

The results which have been accomplished by this general policy in connection with the development of engineering graduates, which has now been in operation nearly ten years, may be conservatively stated as extremely satisfactory. In making this statement the writer does not imply that the results have been satisfactory from the Company's standpoint alone, since from their records it is plainly shown that a very large majority of the young men who have taken their engineering course have profited thereby in every way in the advancement along their engineering and commercial careers.

That the training afforded by the engineering course and the general treatment accorded to the young engineer by this Company are satisfactory, is directly evidenced by the fact that a very large percentage of the engineering apprentices ultimately accept regular positions with them. Many of the managers, heads of departments, and the principal engineers entered their employ as engineering apprentices and have "risen from the ranks."

The course as at present established does not include as an integral part any classes, lectures, or similar adjuncts. The course has been planned primarily for the purpose of giving the young engineer, through actual and practical experience, a training which will make him essentially self-reliant.

The young man now about to graduate with an engineering degree has a decision to make, and in making this decision actual conditions in the world of work must be considered. Only a small percentage of these young engineers can hope for professional careers. The majority will ultimately, through opportunity and temperament, become fixed in administrative and commercial positions. Each graduating engineer, therefore, must decide whether he shall launch himself at once into an independent career or shall by still further training with an already organized commercial concern guide his steps into the life-work best suited to his own individual mental and physical equipment. The greater number of these young men must consider the material advantages likely to ultimately accrue in following the one or the other course.

Usually a man takes a technical course at college because he likes mathematics, science, or engineering. Since ordinary engineering courses have in view principally the idea of imparting fundamental engineering principles, the average man upon graduation is apt to be somewhat narrow and lacking in the broad general knowledge of business principles. It is the object of the Westinghouse Company's engineering apprenticeship course not only to place the young men in touch with workmen and commercial manufacturing experience, but by placing upon them the responsibility for the accomplishment of real work to build up in them a keen sense of commercial responsibility. They must build apparatus which is to be sold; complete commercial tests; dedesign apparatus which must meet actual needs; install plants; erect apparatus, or negotiate for and close contracts covering apparatus which is to do work in the world. These engineering apprentices are no longer in the college class-room or laboratory, where the results of mistakes in calculations or judgment mean no particular personal discredit. They are now in direct contact with the working world. They must think clearly and self-reliantly, and the effect of errors due to lack of ability, study, or sound judgment become quickly apparent and are brought home to them sharply.—*Electric Journal.*

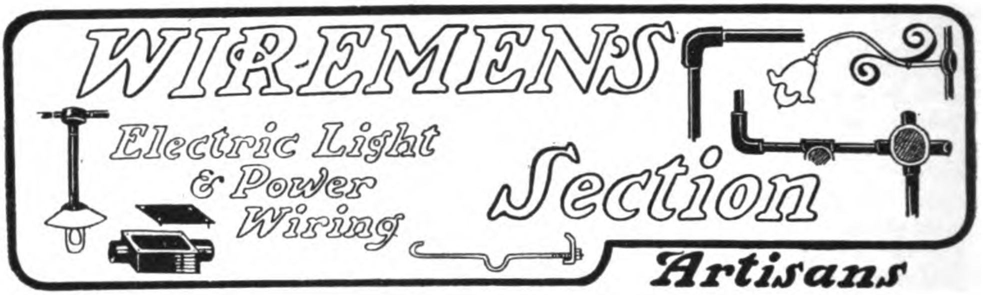
Laboratory Electric Furnaces.

AT the May meeting of the American Electro-chemical Society, Philadelphia, Prof. S. A. Tucker, of Columbia University, dealt with the construction of electric furnaces for laboratory work.

The first furnace described is a granular carbon resistance furnace which is useful for many purposes in laboratory work. In this case the furnace is lined with magnesia brick, the electrodes are of Acheson graphite, and the granular resistor is of crushed gas coke, there being no particular care necessary to grade it to a certain size. However, it makes a great difference whether use is made of fresh coke as it comes from the gas retorts or of old coke which has served for some time as a resistor. If new coke is used it will require a much higher voltage to start the run, and great care must be taken not to get too great a gas evolution during the time that the volatile matter in the coke is being eliminated.

As an example of the many uses to which such a simple furnace may be applied the author mentioned that he had been able to reduce in it any oxide which can be reduced in the arc, with the great advantage over the latter process that the temperature is more easily regulated and a more uniform product obtained.

Full details were given concerning the dimensions and general construction of the furnaces.



Wiremen and Artisans should refer to the World's Electrical Literature Section for classified list of articles on subjects of importance to themselves.

Protection of Motors in Dusty Places.

K. WILLIAMS.

It is practically impossible to exclude grit and dust from open-type motors running in rooms or shops where emery wheels, buffing or polishing wheels are in constant operation, so that the insurance companies have insisted on such motors being enclosed in these places.

Various methods of enclosing open-type motors are in use. One is to place the motor in a box, with slits in the latter for the passage of the belt. Another is to place the motor in an air-tight box, the power being transmitted by coupling direct from the motor-shaft to a counter-shaft; while still another method is to enclose the motor as before, a raw-hide pinion and gears serving to deliver the power.

The first of these methods is faulty, since the slit in the box destroys its usefulness as a dust-excluder. The belt running towards the motor draws with it the dust, which soon settles on the armature and field windings and also on the commutator. In the second and third methods, the grit and dirt can be successfully excluded; but an equally injurious condition results, unless some way is provided for ventilating the enclosure, namely, the heating of the motor.

A novel method of ventilating motors thus enclosed is illustrated in Fig. 1. Here the heated air is drawn out of the boxes through pipes as indicated, while cool air enters at the bottom. All the boxes are connected to common feed and exhaust pipe lines, the former connecting with the lower left-hand corner in the rear of the box, while the hot air is taken out at the upper right-hand corner of the front of the box, so that the motor is thoroughly ventilated. One or two fan motors may be used with this arrangement; one to force the air through the feed pipe to the boxes, or one to force and the other to exhaust the air; in the latter case a fan motor is connected with each pipe line. Another method of accomplishing the same result is to force the cold air in through the bottom of the enclosure and permit the warm air to escape through the top of the box.

A cheaper method of ventilating the

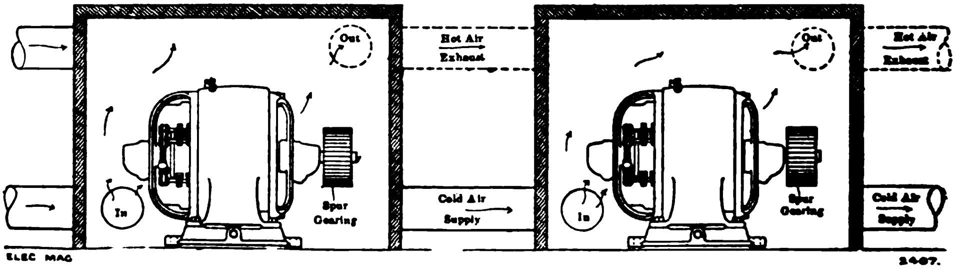


FIG. 1.

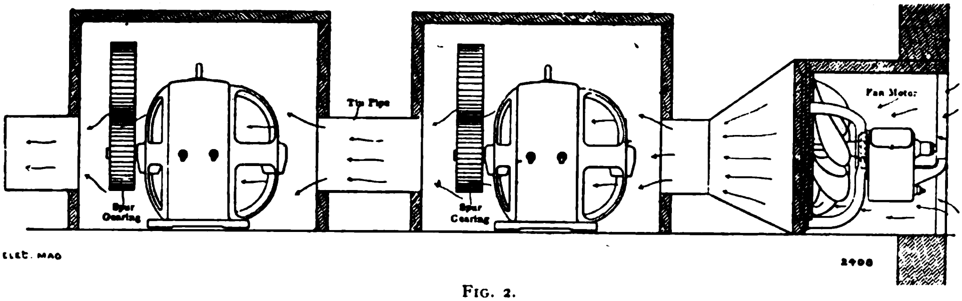


FIG. 2.

motors is shown in Fig. 2. Here the motors are ventilated on a kind of series system. All the boxes are connected as indicated, and one fan forces the air to pass through each box in succession. The method is open to some objection since the air in passing from one box to the next becomes more and more heated, so that if the number of boxes is large, the last motor box in the series receives comparatively hot air. This objection may be overcome by making the series small. It will be noticed from the engraving that the air must of necessity pass through the motor, and it would appear that with this method the ventilation is more positive than by the former methods.

When motors are enclosed in boxes attached or suspended from ceilings, no braces should be used within the box, since these take up room and also prevent the motor from receiving proper attention. Besides, when armatures are to be changed or bearings removed, difficulty is encountered unless the boxes are very large. If the boxes are built snug against the motors, the sides should be made removable, so that the motor may if necessary be inspected from all sides. Fig. 3 shows a motor box suspended from the ceiling and braced on the outside to resist any strains imposed. The doors or sides which enclose the motor are made to slide, so that when it becomes necessary to change an armature or renew bearings, the bottom and top strips holding the sliding doors in place can be taken off. Where only oiling and inspection are required, the doors can be pushed to one side, leaving the motor free for inspection and test.

A faulty method of housing a motor suspended from the ceiling is shown in Fig. 4. In this engraving it will be noticed that the bracing is so situated as to render it impossible properly to inspect the bearings. A motor box thus braced also makes it impossible to remove an armature or to insert a new bearing without first removing the braces.

It is, of course, possible to use enclosed motors in places exposed to grit and dust; but, horse-power for horse-power, the open-type motor is cheaper. To be sure when enclosed in a box an open-type motor cannot carry as great a load as before; but when ventilated as indicated in these sketches, it will carry its normal rated load. Moreover, if encased as shown in Fig. 2 with a blast sufficiently strong, the capacity of the motor can be increased so that with a 5h.p. outfit, 7h.p. and even 10h.p. can be taken continuously without overloading the motor, since by robbing the motor of its heat, the overload limit is also further removed.—*Electrical World.*

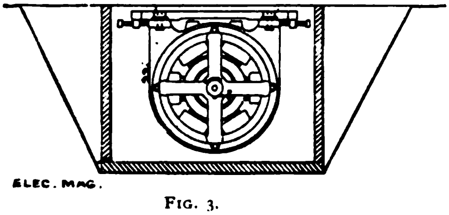


FIG. 3.

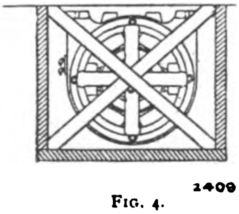


FIG. 4.

◆

Some Troubles of Direct-Current Machines and their Remedies.

W. H. EAGER.

THE notes which follow were made by the writer in connection with difficulties experienced in central-station work with apparatus of various makes. No attempt has been made at classification except that the notes are presented in chronological order.

Sparking at Commutator.—The first case is that of a 100kw. 125-volt generator accused by the operator of continuous and vicious sparking. It was found that no sparking occurred when the commutator had been newly turned, but that sparking began and increased from that time until it became necessary to turn it up again. Inspection of the machine showed that the commutator was smooth but that the brushes were chattering badly. The commutator was very dirty, and this caused the brushes to adhere to the commutator momentarily, thus causing a continuous vibration or chattering. The remedy was to clean the commutator and lubricate it with a few drops of oil.

A Broken Lead.—A 20h.p. variable-speed motor ran nicely at about two-thirds maximum speed. When load was thrown on it "flashed over." At times the motor would carry full load, but any sudden change of load or speed made trouble. The machine was tested for short-circuit by the use of a lamp and cord. Next the insulation was tested and found to be in good condition. The designers were interviewed to discover whether any feature of the machine inherently tended toward sparking. The trouble was finally found to be caused by a broken lead which made contact at low speeds, but which pulled apart at high speeds or by magnetic influences at sudden load changes.

Irregular Neutral Point.—A 250kw., 550-volt generator sparked at the brushes on one brush stud only. Shifting the rocker arms removed the sparking at this stud, but at the same time produced sparking at all the others. Geometrically considered, the stud was found to be properly placed; but owing to a slight displacement of the corresponding pole-piece, the brushes of this set did not come on the neutral point when the remaining brushes were properly placed. The sparking was entirely eliminated by setting the brushes on the neutral point by the voltmeter method, although this necessitated placing this set of brushes out of place nearly one-eighth inch by the tape.

An Earthed Armature.—Another motor, which had been operating for a number of years under a very uniform load, suddenly began to blow its fuses. The capacity of the fuses was increased until it exceeded the normal rating of the motor by 50 per cent. The commutator flashed badly, and the machine heated quickly. The belt was taken off and the motor allowed to run idle, but even then it took a large current. This indicated what was afterwards found to be the case—a badly earthed armature.

Another Broken Lead.—A generator was flashing badly at the brushes and burning the commutator, due to an armature lead which had broken off near the commutator. A temporary repair was effected by "dead ending" the defective coil and soldering together the commutator bars at the point where the break occurred. Where a break of this nature is present, but not readily discernible, it may be located by testing with a lamp and cord.

An open lead in a motor armature produces results similar to the same trouble in a generator. If the machine can be run without burning the commutator too badly, a means is thereby acquired of readily discerning the location of a broken lead. When run a short time, it will be found, after stopping the motor, that two insulation strips have been burned. The broken leads will be found to belong to the bar which is behind the burned insulation; "behind" being a term based on the assumption that the direction of rotation is forward.

Short-circuited or Reversed Coils.—A trouble, caused by conditions differing from the last case but sometimes producing a similar effect upon the operation of a machine, is that of a short-circuited or reversed coil. A penknife held suspended midway between the poles will be jerked as the defective coil passes beneath it.

The foregoing examples are for the most part simple in cause and effect. Scarcely one, however, had it been neglected, but would have continued from bad to worse. Breakdowns of more serious nature, such as burned-out armatures, short-circuited armatures, broken leads, and the consequent burning of commutators, reversal of field, commutator flats, vibration, noise, &c., are generally made possible through the neglect of smaller matters such as have been enumerated.

Never let a machine spark. If it does, stop at once and locate the trouble, but do not let a machine keep on sparking day after day. It eventually means a new commutator, and before that an endless supply of brushes.—*Electric Journal.*

MEDICAL ELECTRICITY.

Recent Developments in Radiography.

GEOFFREY PEARCE.

THE unrealistic appearance of an instantaneous photograph taken of a quickly moving object, such as a horse galloping or a man running, is familiar to everyone.

The photograph presents to us an entirely different idea to that which we are accustomed to associate with movement.

The explanation is simple and obvious. The instantaneous photograph represents a fractional part of the movement which is taking place, whereas with our eyes we see the continuity of movement and the completed action; that is to say, the appearance of a moving object viewed momentarily is entirely different to the appearance of that object when the complete action is seen.

The human body is partly built up of various organs which are in a continual state of motion due to respiration and circulation.

The X-ray photograph should therefore theoretically be instantaneous so as to represent the shadows of those organs (which up to the present it has been possible to show) in a fractional part of their movement, or in other words as nearly in a state of rest as possible.

It is obvious, therefore, with the foregoing in view, that in order to produce skiagraphs

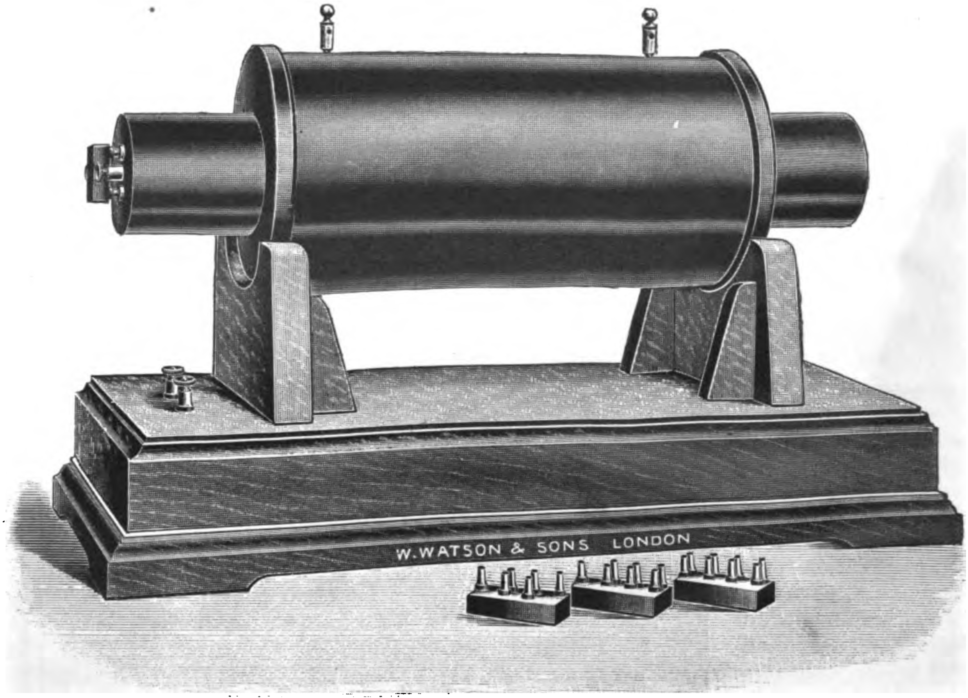


FIG. I. INTENSIFIED INDUCTION COIL.

which will show shadows of the actual conditions existent, it is necessary to cut down to the narrowest limits the duration of exposure.

There are several difficulties in this connection, some of which have been overcome, others partially so, and some still exist.

Reverting to the parallel of ordinary photography again, rapid exposures are only obtained with special apparatus designed to produce them, and then successful results are only arrived at under the most favourable conditions, that is, with a bright light, &c. One of the most important instruments is the high-aperture lens, which gathers the utmost possible light so as to produce the greatest effect on the photographic plate.

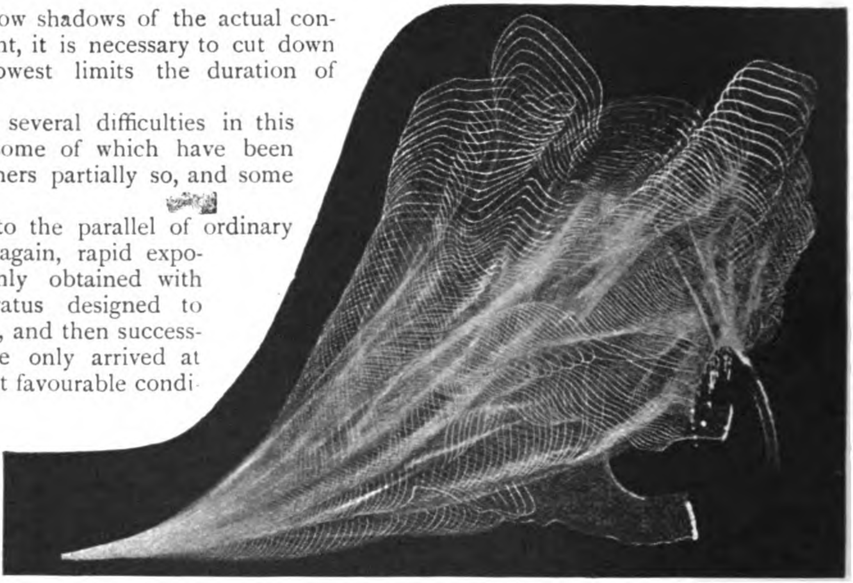


Fig. 2. Discharge of Intensified Induction Coil.

In radiography one has to deal with X-ray plates, but in the place of ordinary light the radiation from an X-ray tube is used. The X-rays, however, are incapable of being refracted in the manner that ordinary light is by the photographic lens, and therefore nothing can be effected in the direction of gathering or concentrating the radiation as in the case of ordinary photography.

The only course open, therefore, is to produce the utmost light, or in other words the most intense and actinic radiation possible.

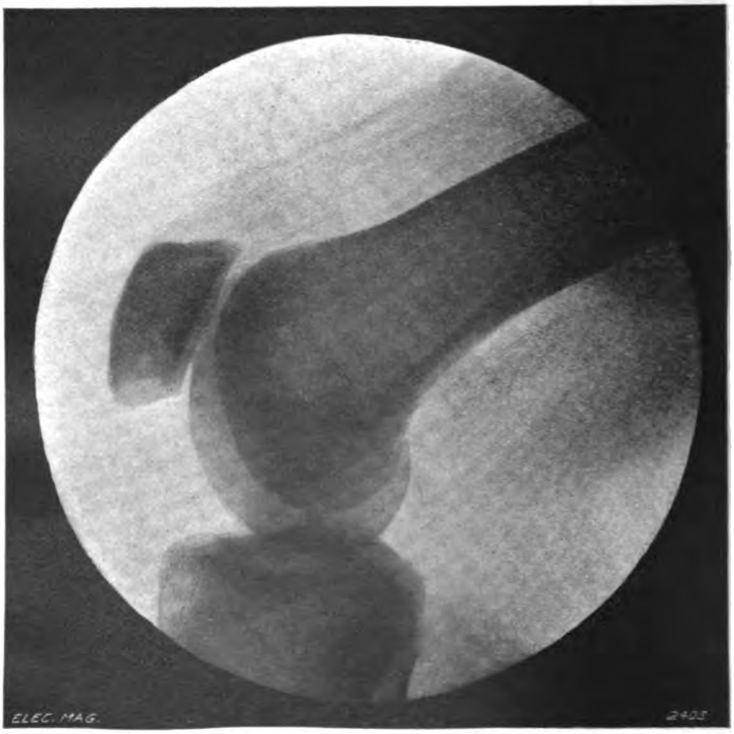


Fig. 3. Knee Joint.

The high tension necessary to excite an X-ray tube is with comparatively few exceptions obtained from the Rhumkorf induction coil. In order to render this instrument more efficient for radiographic purposes, it has been necessary to remodel it so as to make it capable of a very large output of energy.

The intensified induction coil introduced by W. Watson & Sons illustrated in Fig. 1 is an instrument built on the new and following lines:—

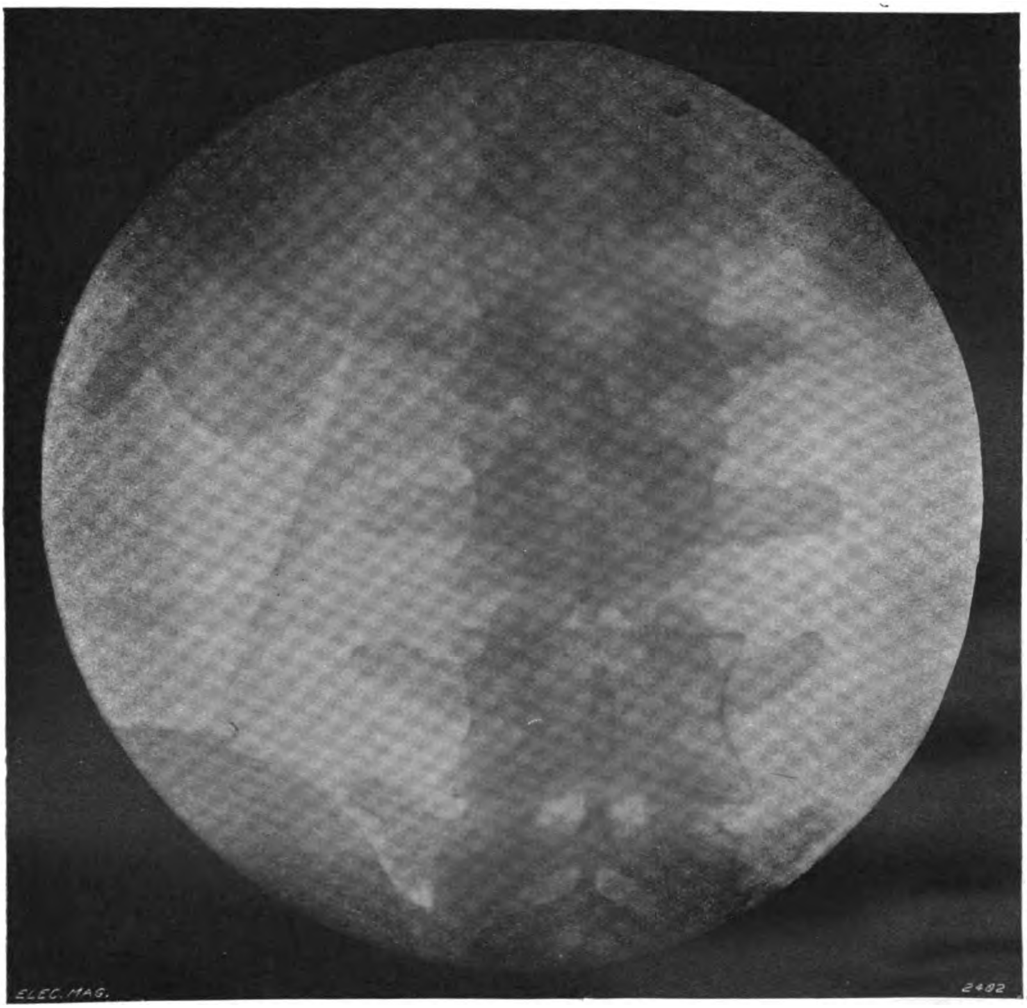


Fig. 4. Lumbar Region.

In the place of the usual bunch of soft iron wire forming the core, a number of transformer plates of various widths are used. The primary is wound with a much thicker wire than usual and in several layers. These are tapped off at various points and brought to sockets at the end of the primary tube; by means of plugs fitting into these sockets the various layers can in a few seconds be connected in parallel, series parallel, or series, in order to produce the correct self-induction under different conditions. The secondary is smaller than usual, and wound with a comparatively thick wire. Induction coils constructed on these lines do not produce a very long discharge, which tends towards a high tension, but rather a short thick heavy spark. In the early days of radiography, workers, with the view of reducing the exposure as much as possible, employed long spark coils of 20in. to 24in. spark length, but the results produced were disappointing, and certainly did not justify the increased cost, great size, &c., of coils of this description.

For rapid-exposure radiography a high-tension discharge of large capacity is required, and it is the type of induction coil, the construction of which has previously been described, which produces it.

The illustration Fig. 2 is reproduced from a photograph taken of the discharge produced by a nominal 12in. spark intensified induction coil working with a Wehnelt electrolytic interrupter. The length of the discharge is 16in., showing the enormous output of the coil.

The Wehnelt type of chemical interrupter is used exclusively for short-exposure radiography in conjunction with high-pressure electric lighting supply up to 250 volts.

The primary is connected in series with the Wehnelt interrupter and the mains without any resistance in circuit.

The current consumption varies from 15 to 25amp. at 200 volts according to the anode surface of the Wehnelt interrupter exposed, and so perfect is the insulation of the coil that this current can be passed with impunity.

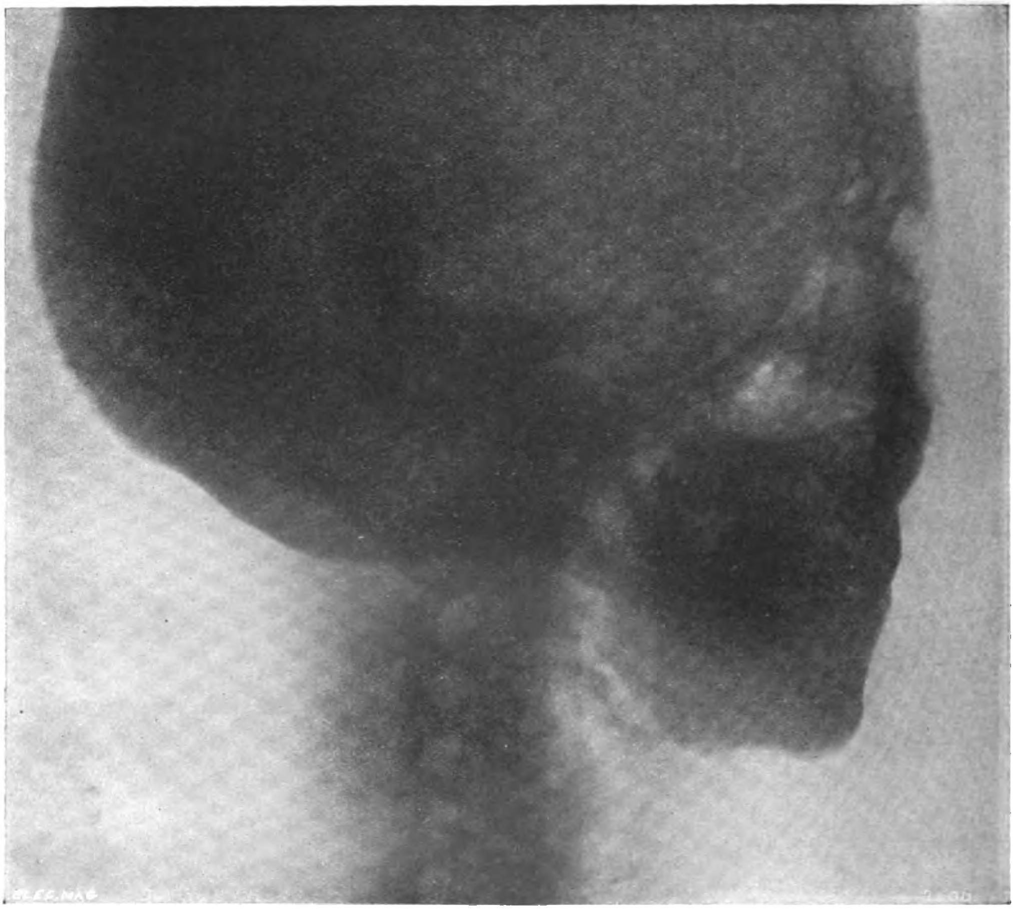


FIG. 5. HEAD AND NECK.

The maximum output of this new type coil is such that more energy is produced than any type of X-ray tube at present can stand for more than a few seconds at a time, *i.e.*, the energy is practically unlimited, so that the utmost radiation can be obtained from a given tube.

The most satisfactory results are obtained with an X-ray tube of low internal resistance, that is with an alternate spark-gap of 2in. to 3in., the high-tension current passed being about 20 to 25 milliamperes. In order to stand the heating effect of this current a tube with heavy anode is necessary.

Under these conditions the average exposure necessary to produce satisfactory skiagraphs varies from one second for the thinner parts, such as the hand, &c., to five seconds for the abdominal section.

By means of these short exposures, skiagraphs of splendid definition, contrast, and detail can be obtained. Shadows of the soft parts, such as the kidney (see Fig. 4) or the ear (as in Fig. 5), are clearly shown, which with long exposures are entirely lost.

Of course with these heavy discharges the life of the X-ray tube is comparatively short, but the superior results amply justify the additional expense.

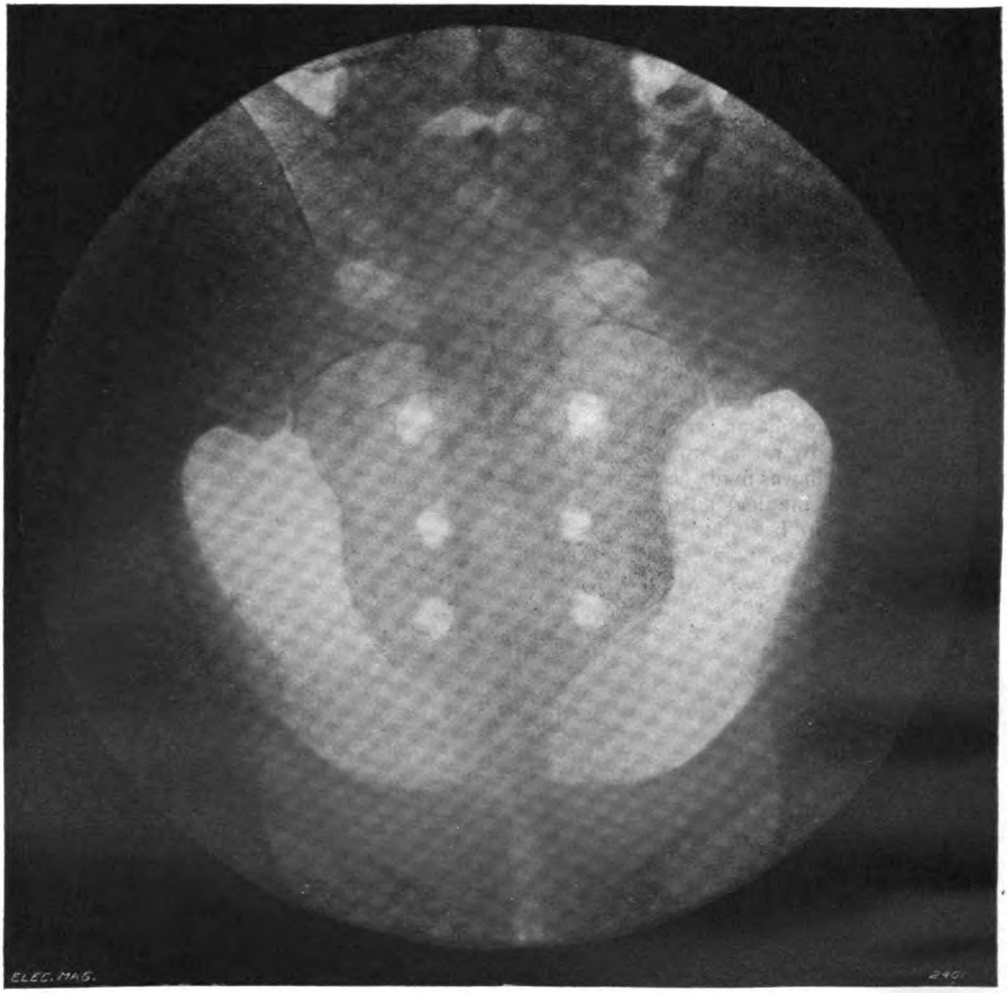


FIG. 6. PELVIS.

No doubt in the near future it will be possible to obtain a tube which will meet the demands of the worker with the heavy discharge induction coil.

Exposures of minutes' duration have been replaced by exposures of seconds; the next step will be exposures of fractions of a second.

The Radiant Heat and Light System of Medical Treatment.

H. J. DOWSING, M.I.E.E.

ELECTRICITY has been used for many years as a means of electrical treatment—principally in its direct application to the human body—but it is only of comparatively recent date that the electric current has been applied to the production of light and heat in such a form that it could readily be used for medical purposes. The total absence of flame, fumes, and danger, its ready control, its almost instantaneous action, all tend to make electric heating the ideal system, especially where sickness is concerned.

The ordinary method of heating a resistance wire and this in turn heating the air, or other surrounding substance by contact, is the simple way of using electric heating, but the most effective method, and certainly the most popular, is to use electric heat lamps of a special character, and project the heat from same by radiation. The application of this system was made at the suggestion of a well-known medical authority, and it is called the radiant heat and light system of treatment. Besides using heat, a certain amount of light is produced with the heat, and the action of the light rays is an important factor in the treatment. The older system of applying heat for medical purposes was solely by contact, with the aid of some heat-retaining medium, such as the common poultice, hot water, or even air.

With radiant heat, however, the matter is quite different, as we deal with "rays"; it is, after all, the oldest system in the world, for in this way the earth receives its heat from the sun. The problem of heat transmission from the sun has puzzled scientists of all ages, but we have learnt some facts about the matter, one of which is that radiant heat can pass without any conducting medium, if we except the all-pervading ether. But there are conditions which must be observed if we are to transmit radiant heat. All substances radiate heat if their temperature is above that of the surrounding air or objects, but the difference in temperature of most substances in ordinary use is small, hence the heat radiations are feeble. The temperature of the sun's rays as they reach our planet may be anything up to 200deg. F. or even more, and practical estimates from measurements taken by Pouillet and Herschel prove that the energy is equal to one horse-power received by every three square yards of the earth's surface.

But the sun's rays (although producing heat energy to this extent when absorbed) are not by any means heat rays alone. We may call them vibrations of the "luminiferous ether," but until they are received and absorbed, the heat effect is not properly felt. Thus an ordinary thermometer will measure the air in contact with it, but not the luminous heat rays, which must be received on a blackened bulb or sun thermometer in order to ascertain their temperature. Tyndall performed a very pretty little experiment which proves the correctness of this. Taking an ordinary thimble which he coated on the outside with lampblack he caused a beam of light to fall upon it, but took care that the light should first pass through a vessel of water in order to extract all the heat from it. After a time the water in the thimble boiled, and yet nothing but a beam of light had been allowed to reach it. What had happened was this: the light rays had been absorbed and in the process turned to heat. Greenhouses are heated in the same manner—light passes through the glass and falls upon the flowers, shelves, walls and ground, where it is received. The resulting heat does not escape owing to the fact that glass only transmits light or luminous heat rays. It is this fact that makes the glass screen of use. Non-luminous heat is not transmitted, in other words glass is practically opaque to dark heat rays.

The flesh of the human body is in many respects like glass. It will allow luminous heat rays to pass, but holds on the surface most of the long heat rays of low temperatures. A knowledge of this fact is a most important one in the application of heat to the body. Even in the simple process of warming the person it is well known that a blazing fire or bright sunshine will have a far greater warming effect than any form of hot air. The heat rays penetrate the clothing, and after that the flesh, warming in a few seconds far more effectively than contact with hot air can do in hours.

In order to ascertain the difference in the effect of heating by means of contact with air and luminous heat rays, an experiment was carried out by Dr. Bain of Harrogate.

A dog, having been etherized, was used as the subject of the experiment, and the hind leg was placed in a Dowsing radiant heat apparatus using luminous electric heaters. The results were compared with similar experiments previously carried out in which obscure heat or hot air only was employed. The following figures give the results, and prove conclusively the greater heating power of luminous electric heaters. During the experiment the general temperature was raised 3.5deg. Fahr., and the local temperature 15.2deg. Fahr., while the temperature of the enclosure attained a maximum of 250deg. Fahr. The figures previously obtained with the hot-air box were as follows: body temperature raised 1.8deg. Fahr., the limb temperature raised 6.6deg. Fahr., while the temperature of the box was 300deg. Fahr. Dr. Bain, in giving the result of this experiment, states that "the difference in temperature, both local and general, produced by the two methods is most marked, and so far as the curative effects may have a thermal basis, weighs in favour of the Dowsing system."

Heat applied to the body by contact is carried through the flesh by conduction, until the heat applied is gradually lost in the circulatory system. On the other hand if powerful heat rays are directed upon the flesh a large number penetrate into the body (in many respects like X-rays) and the depth to which they penetrate is much greater than by any other mode of heating.

In applying heat by contact to the human body, we soon arrive at a point where we must limit the temperature, otherwise damage to the flesh will result, blisters will form on the skin, which becomes parched and even charred. It is found that heat applied by means of moist air cannot be borne at a much greater temperature than 115deg. to 120deg. Fahr. but with dry air 250deg. or more can be stood. On the other hand with direct applications of heat by means of luminous heat rays, temperatures of 300deg. Fahr. or more can be borne without discomfort, as table in Fig. 1 shows.

TEMPERATURES WHICH CAN BE BORNE BY THE HUMAN BODY.

400	Radiant heat bath, maximum bearable heat for full body bath.
300	Radiant heat. Bath comfortable.
240	Very hot Turkish bath.
212	Water boils.
200	
180	Hot air dangerous to breathe for lengthened periods.
130	Hot air bearable.
120	Vapour baths unbearable.
115	Vapour baths painful.
105	Vapour baths exhaust rapidly.
100	
98	Blood heat.
76	Summer heat.
32	
0	

FIG. 1. AN INTERESTING FAHRENHEIT THERMOMETER.

In order to get great radiation it is necessary to raise the temperature of the radiator to such a degree that it becomes partially luminous. For instance a rod of iron will radiate heat much more readily at a white heat than at a dull red heat.

This table shows that the loss of heat by radiation increases very much more rapidly than the difference of temperature.

HEAT GIVEN OUT BY CONTACT AND RADIATION (DULONG).

Temperature of the heated body.	Temperature of air.	Difference of temperature.	Ratio of heat lost at different temperatures by	
			Radiation.	Contact of air.
490	60	430	3.10	1.980
960, red just visible	—	900	12.68	2.348
1320, dull red ..	—	1260	42.70	2.450
1680, cherry red ..	—	1620	154.50	2.693
2220, clear orange	—	2160	1159.00	2.880
2580, white, bright	—	2520	4604 00	2.985

It is well known that in analysing the spectrum the greatest amount of heat is shown to be in the dark portion of the

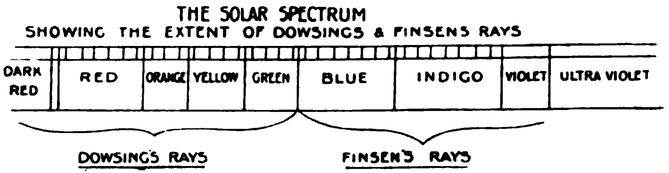


FIG. 2.

spectrum, just before the low red luminous portion is reached, whereas Finsen's rays are at the violet end (see Fig. 2). These long heat waves are not very penetrative, and we know that a blazing fire, with its luminous heat, is far more efficient in its warming effect on the human body than a dull red fire, owing to the powerful heat radiations emitted.

The radiant-heat system of medical treatment was originally introduced to supplant hot-air baths using highly heated air in which parts of the human body were treated for curative purposes, and mainly to secure free action of the pores of the skin. The heaters are made in the form of powerful electric heat lamps, the temperatures of the filaments — radiating bodies — being over 2000deg. Fahr. As heat radiation is subject to the law of inverse squares, the temperature of the heat rays given off decreases very rapidly with the distance, and it is found that a distance of about 10in. to 15in. is a suitable one for applying this system of heat to the human body, and the temperature of the heat rays falling upon the flesh is found to be about 300deg. or 400deg. Fahr.

But, as stated above, luminous heat rays penetrate the skin to a larger degree, and consequently only part of the heat radiations remain on the surface, a good proportion passing through this covering into the flesh and deeper parts of the body. As the flesh is ordinarily a bad conductor of heat, the luminous heat rays receive great resistance in their passage through the body, and are like electricity passing through a resistance reduced to "heat" pure and simple. This has been aptly called by a medical critic a "degradation" of energy.

What is the action of light rays on the skin? Authorities tell us that the pores of the skin open to the action of light, like a flower to the sun. Indeed, this is very easily proved, for a powerful light thrown on the body will cause perspiration to take place at as low a temperature as 78deg. Fahr.—or 20deg. less than the temperature of the human body. That is, the pores open and perspiration, visible or otherwise, takes place. On the other hand, before such an effect is produced by contact of hot air only, a temperature of from 130deg. Fahr. to 140deg. Fahr. is necessary, and then the perspiration is of a very feeble character. The penetrating heat rays will produce a deeper-seated action, and if the temperature applied is the same, the perspiration is much more profuse by means of luminous heat rays than hot air only. The luminous heat rays penetrate to the deep-seated organs of the body, and as heat is the remedy *par excellence* for pain it follows that pain can be readily relieved by the direct application of these heat rays.

If heat is applied to the body by contact it is conducted very slowly through the flesh, and owing to the network of blood-vessels below the skin, the heat is largely absorbed and distributed over other parts of the body. The only heating effect obtainable in this way is by the circulation of the blood, but the increase in temperature is very small. On the other hand, with direct heat radiation, any part of the body on which the heat rays are directed may be raised in temperature to an appreciable extent, and if the whole body is subjected to the luminous heat rays, the temperature may be readily increased from 1deg. to 2deg., or even more. In fact, it is not infrequently the case that even partial application of the luminous heat treatment will increase the complete body temperature. This was believed to be impossible previous to the introduction of this system.

How does the action of direct luminous heat affect the body? Dr. Gueynot, of Aix-les-Bains, gives the following results from many tests carried out by him:

1. Very marked redness of the skin.
2. Very abundant perspiration, and the elimination of considerable quantities of carbonic acid by the lungs.
3. Acceleration of the pulse, and increase in the temperature of the patient; these two phenomena are less marked in proportion than with the Turkish baths.
4. Increase of the volume of solid materials of the urine, especially of the urea and uric acid.
5. Greater activity of the functions of general nutrition, and the elimination of organic oxidation products.
6. Penetrating power of the heat rays much more than that of obscure heat.
7. Marked excitation of the skin by the chemical rays, which possess pronounced bactericidal properties.
8. Special action of the luminous rays on the red globules of the blood, augmenting their number and thus increasing their power of oxygenation.

Some curious facts have been discovered

in the application of this treatment from the ten million applications which have already been given in various parts of the world. The luminous heat rays must not be of a too luminous character, *i.e.*, they must not be produced too high up the spectrum, otherwise actinic rays are added which have a distinct use, but are harmful to the skin. Finsen proved this as he used these rays only for the cure of lupus. Many hundreds of experiments were made in conjunction with medical men to discover from which part of the spectrum the rays could best be obtained which would be most beneficial in the particular treatments for which heat was required, and it was found that to take the luminous rays above the middle of the spectrum was unwise, as there was danger of injuring the skin. The upper rays readily produce sunburn and freckles and are found to be not so penetrative. The skin varies considerably in different persons. Some skins are particularly sensitive to heat rays, while others are the reverse. The black skin of the negro would naturally absorb and so largely obstruct the passage of the luminous heat rays, thus preventing their penetration to other parts of the body.

Light has a germicidal action according to its intensity, and cultures exposed to a strong light are killed more readily than by heat. Professor Marshall Ward found that the spores of anthrax were prevented from developing into colonies by exposure to light, and were destroyed by repeated exposures to the direct rays of the sun. Although it may not be possible to get sufficiently powerful light rays to penetrate the skin to effect results such as the above in deep-seated parts, yet the action of the light which does penetrate is very effective in destroying morbid matters, probably

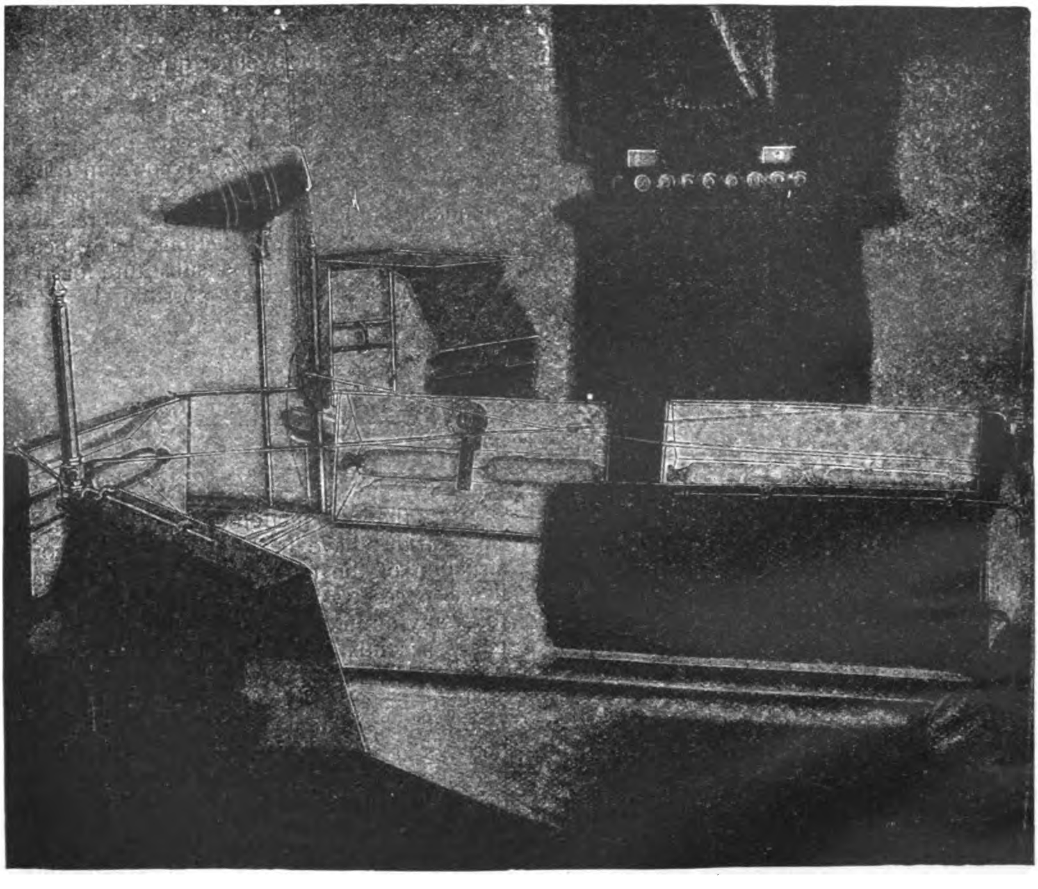


FIG. 3. COMPLETE RADIANT HEAT AND LIGHT APPARATUS.

causing disintegration of deposits, and increasing the changes that are going on in the body. The increased circulation too aids in this process, and in the removal of matter that has been acted upon by the light and heat rays.

Light is also a counter-irritant, and like the mustard plaster draws the blood from the internal parts to the surface. This action takes place almost immediately the rays are applied, and is one of the first effects noticed, giving almost immediate relief to the congested parts.

The temperature of the blood is raised to a small extent, the circulation increases, and a process of "burning up" and "washing out" commences, which is continued during the treatment; thus the ureates which have been deposited in different parts of the body are dissolved, and removed from the system by the pores and general circulation.

The apparatus, which was first developed in accordance with the above theory and practice, and made after innumerable experiments, consisted at first of appliances in the form of metal reflectors of a particular shape, fitted with large electric heat lamps and made in such a form that they could be readily applied to the limbs or parts of the body, but the present apparatus is principally made for giving general body treatment, although local appliances, Fig. 4, are still in use.

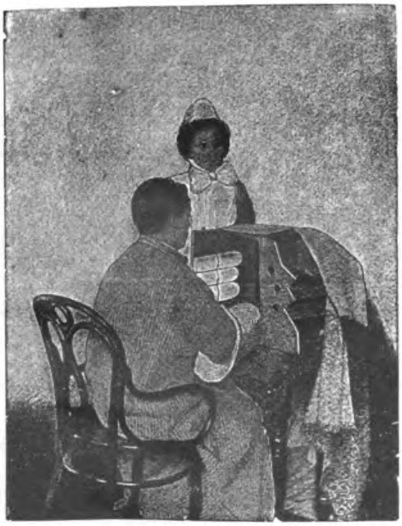


Fig. 4. Radiant Heat and Light Apparatus for Local Treatment.

Fig. 3 illustrates the full radiant heat bed treatment with controlling rheostat, connections, &c. During treatment, a porous cloth covering lined with asbestos is thrown over the whole. The patient is thus reclining in an enclosure, but being subjected to the direct rays of light and heat from the heat lamps surrounding him.

The reflectors are of a special patented form, and are made to reflect and disperse the heat rays, so that the interior of the bed is equally heated, and flooded with rays of light and heat.

A large proportion of the luminous rays penetrate the patient under treatment, and tend to increase the metabolism of the body, increasing the blood stream, and unloading the congested parts of morbid products.

The treatment is found to be most effective for all uric acid troubles such as gout, lumbago, and similar complaints, also for rheumatism, rheumatoid arthritis, sciatica, sprain, neuralgia, and many nerve troubles.

It is frequently averred by patients that there is an electrical effect quite apart from the heat and light treatment carried out, but nothing is claimed in this respect. It is noticeable, however, that many persons receive a tonic effect quite unknown in other heat applications, where exhaustion is frequently followed by extreme depression. The luminous heat radiations have been proved to be a very good substitute for the sun bath without any possible harmful effect.

Practice with X-Ray Work.

C. W. J. MORLEY.

Since the introduction of the X-rays great strides have been made in the construction of the apparatus, so that whereas it was necessary to give exposures from ten to twenty minutes, it can now be done in as many seconds or even less, in fact some X-ray workers have for many years been able to take instantaneous radiographs of the heart, chest, and other parts of the human body, and any worker who wishes to do likewise can easily do so by using the electrolytic (Wehnelt) interrupter, and working from the electric light mains.

By using the electrolytic interrupter the spark from any ordinary induction coil is greatly intensified, and especially if the coil is fitted with a variable primary. Should, however, any worker's coil not be fitted with a variable primary, the makers can fit one at a very small extra cost.

There is no doubt that the electrolytic break gives marvellous results, but, like all good things, it has its drawbacks, one being that it is not very suitable to use for treatment, another, that it is very hard on the vacuum tubes, and, moreover, it also requires a certain amount of understanding before it can be used with success.

We need not here discuss the construction of the various makes of electrolytic breaks, but it is sufficient to say that any maker of X-ray apparatus supplies them to work from the direct or alternating current from 100 volts to 250 volts. They can be used direct from the mains with or without a rheostat in circuit, but it is always as well to have a suitable rheostat, as by this means the operator has greater control of the apparatus.

A valve tube should always be used in circuit with the X-ray tube when using the electrolytic break, and the X-ray tube should be preferably a heavy anode or a water-cooled one. For general practice and hospital work we cannot with confidence recommend the electrolytic interrupter unless the operator is very skilled at his work, as the tubes are easily ruined, and should an accident happen, such as the bursting of a tube during an operation, owing to the excessive current, the results might be disastrous to the patient, and the operator find himself involved in heavy damages.

There are a number of good mercury interrupters on the market which give almost equal results to the electrolytic break without any of its drawbacks, in fact the results obtained are almost as rapid.

Of course the X-ray tube must be a good one and should work with not more than a 4in. to 6in. spark. In short exposures it is necessary to have the X-ray tube rather closer to the patient than when giving long exposures, with the result that good definition is not obtained, but in kidney and renal calculus work the definition does not matter. As a prominent X-ray worker once truly said, "It is not the picture to go for, but the stone."

Another important addition to an X-ray outfit is a tube box that is opaque to the rays, and this box should be fitted with a diaphragm. There are many advantages in having the tube enclosed in a box and using the diaphragm, one being that it entirely prevents the rays escaping to the operator, and the diaphragm, which can be easily adjusted from a 3in. to a 1in. aperture, cuts off the escaping rays that otherwise tend to fog the plate, and at the same time produces a much sharper picture; in fact it is quite possible with this diaphragm to see a stone in the kidney on the screen provided the X-ray room is totally dark and the operator has been in it some time in order to get his eyes accustomed to the darkness.

In our next article we will endeavour to publish a few radiographs taken with the electrolytic and mercury interrupters with a variable primary coil with a few seconds exposure.

(*To be continued.*)

* * *

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MANUFACTURING Progress

A classified list of articles important to Manufacturers will be found in the World's Electrical Literature Section.

◆

The Van of Progress.

S. Smith & Son, Ltd., London.

THERE is no business house of higher international reputation than Messrs. Smith's, of London, whose products are known the world over as the perfection of the watchmaker's art. Long established, yet keeping ever up to date, this British firm enjoys a growing prosperity which cannot but be the envy and study of alert business men. And when one comes to look for the reason of this greatness it is easily found; the most telling factors are, firstly, "in all things keep abreast of the times," and secondly "one quality only, and that the absolute best." As to how far these maxims have entered into Messrs. Smith's business is evident from a look into their new works at Watford. We recently had the opportunity of passing through these shops, and saw the "Perfect" speed indicator and the "Taximeter" under manufacture. These two instruments are accessories of the motor-vehicle, and in taking up their manufacture Messrs. Smith's have shown the business foresight and enterprise of keeping pace with time and its changes.

Modern life and work becomes more and more a striving after detail; the care of small things is of ever-increasing importance. In mechanics generally it is the saving of seconds, the acceleration of speeds, the striving after that last decimal point in accuracy or efficiency which gain the ascendant. Where indications or records of small powers are wanted, the skilled watchmaker finds congenial and successful scope for his labours in the designing and making of the necessary

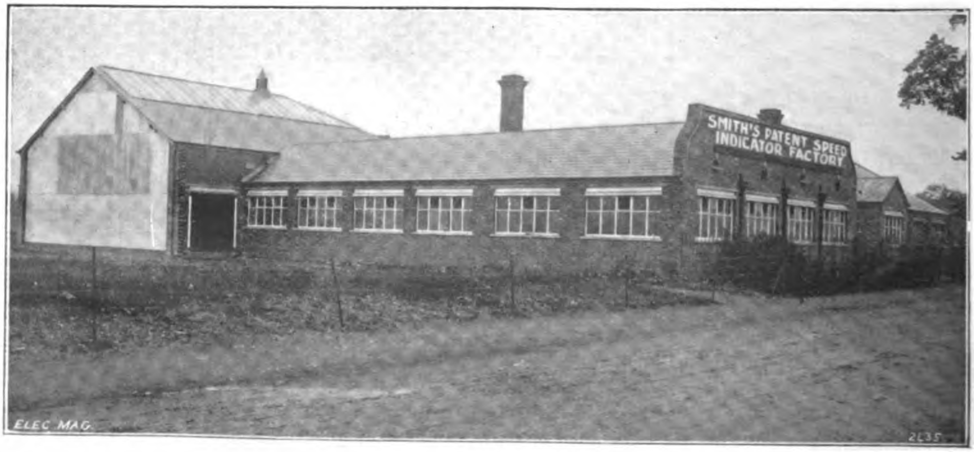

FIG. 1. THE NEW SPEED INDICATOR FACTORY OF MESSRS. S. SMITH & SON, LTD.

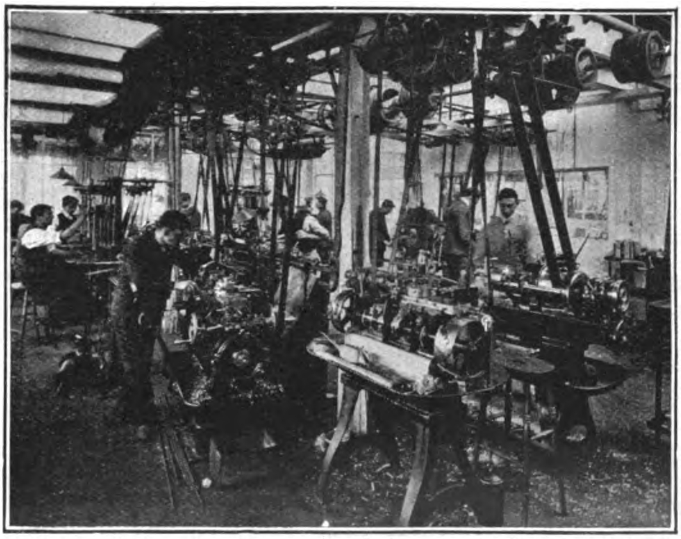

Fig. 2. The Automatic Machine Shop.

gauge or instrument; after all he is indeed the engineer of fine-grade work, and there are very many profitable opportunities other than chronometer-making afforded him in these days of detail.

It is not surprising therefore to find that Messrs. Smith are engaged in the manufacture of motor-car speed-indicators and taximeters; but, all the same, it is to be noted that in this departure there is full evidence of the commendable commercial wisdom of being actively alive to progress.

The illustrations herewith show to some extent the happy result of this spirit of enterprise. The firm has been compelled to build works on purpose to fill orders for these two new devices alone. Twice already have these works been extended; they came into existence only two years ago, and even now they are taxed to their utmost capacity.

Under the genial guidance of the principal of the firm, we were privileged to study at our leisure and in a full inquiring vein the entire works. Situated in the glorious open country of the Hertfordshire border near Watford, a nest of one-story shops with ample roof and side-lights, it forms an ideal factory. Consistent with this no restriction has been placed on first cost of the equipment. The machine tools are examples of the most modern and approved types to be found in this or any country for their particular classes of work. The general appointments and fittings are all that could be desired. Electricity is used throughout for power and for lighting. In short the works are thoroughly typical of advanced modern methods. Little wonder, therefore, that the men engaged therein are able to do themselves justice and produce instruments of irreproachable workmanship. That this perfection of works arrangement and equipment is sound, good business is indisputable in face of the profitable results to the firm and the cheerful air which characterised the industrious, efficient staff—a feature the more apparent because unfortunately rare in most manufactories.

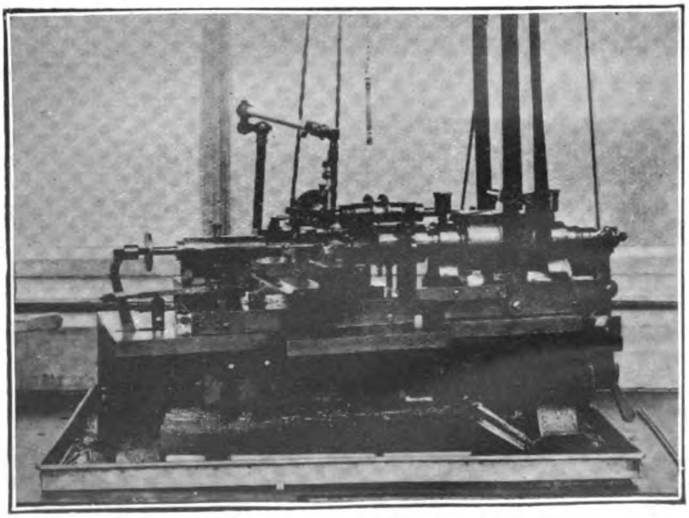

Fig. 3. An Automatic Screw-making and Slotting Machine.

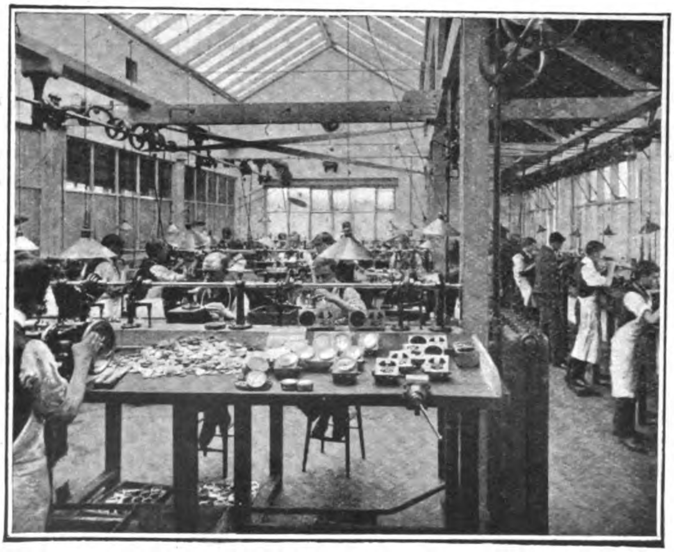

Fig. 4. The Examining and Calibrating Shop.

"Perfect" Speed Indicators.

The particular feature of Messrs. S. Smith & Son's speed indicator is its extreme simplicity of design. It is an improved adaptation of the centrifugal type of indicator by means of which a large-scale range and permanent accuracy are obtained. The instruments are made for various speed ranges of from 5 to 40 miles an hour up to and above 10 to 100 miles an hour.

The indicator proper is driven by a mechanism consisting essentially of a flat aluminium ring screwed to the wheel of the car, and on which rides a pulley, held against the ring by a flat spring. The pulley is provided at its periphery with a rubber tyre, which not only ensures silent running, but also serves the very useful purpose of increasing the friction between pulley and ring. When the car is in motion the pulley is rotated by friction, and transmits its rotation, by means of a flexible steel wire, to the speed indicator proper, which may thus be placed in any position convenient to the driver. The steel wire is enclosed in a flexible metal tube. Within the case of the speed indicator there is a small centrifugal governor having three flying weights, which is driven from the steel wire above referred to through a train of toothed wheels. The axle of this centrifugal device is horizontal, and consists of three parts, which telescope within each other. There are also three springs of different size, which successively come into action as the speed increases, the weakest spring being compressed first. After a certain speed has been attained, the weakest spring is prevented by a suitable collar from being compressed further, and the next size of spring comes into action. After a further increase of speed, the third spring is also used. This three-spring device forms a special and most valuable feature of the instrument; its advantage lies in the fact that it permits of an approximately even scale of readings over a wide range. The movement of the centrifugal governor is transmitted to the dial hand by a grooved sleeve, or cylindrical rack, and a pinion, and any backlash is taken up by a spiral spring which continually tends to move the hand back to zero. The latest form of indicator is fitted with a mileage register up to 10,000, and a trip recorder which can be set to zero at will. The indicating hand is placed in the centre of the dial, and indicates in the

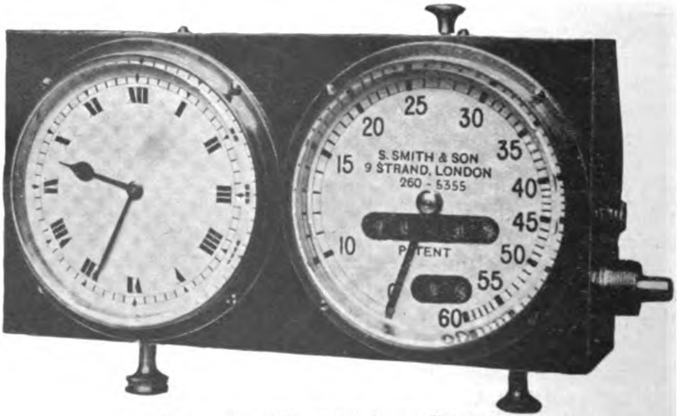

Fig. 5. The "Perfect" Speed Indicator.

standard design all speeds from 10 to 60 miles per hour. There is also provided a supplementary hand which serves as a maximum speed indicator; this is released and returned to zero by pressing a button on the top of the instrument. Lubrication is simple, and the indicating hand is unaffected by vibration. The makers supply standard sizes of pulleys and rings, which are suitable for any make of car, the aluminium ring being marked in plain figures, with the distance from the centre at which the pulley has to be placed in order to give an accurate reading with the corresponding sizes of car wheels. This does away with a great deal of difficulty with those dealers who can only keep a small stock of such instruments; and it is claimed this is practically the only instrument of its kind which can be supplied for any size car wheel with the same parts.

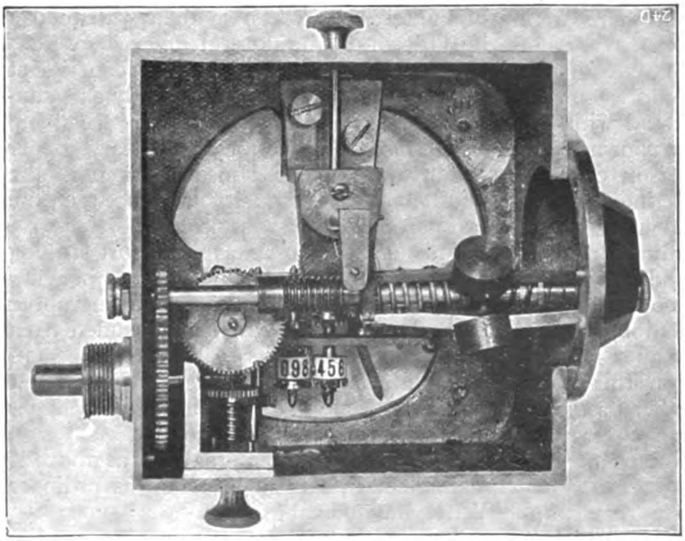

Fig. 6. The "Perfect" Speed Indicator—Interior.

The "Perfect" speed indicators are supplied either simple or with auxiliary time and distance indicators assembled in one case. The various types are: The simple speed indicator, showing speeds varying from 5 to 40-100 miles an hour, fitted with or without the supplementary hand; the new and most popular type, *i.e.*, the speed indicator and watch combined; the speed indicator and electric communicator combined; and the "modèle de luxe," or triple instrument, comprising the speed indicator, motor watch and communicator all in one handsome instrument.

The Taximeter.

With the advent of the motor-cab Messrs. S. Smith & Son were quick to grasp the opportunity for advancement by designing and perfecting a distance-time and fare indicator or "taximeter" which should fulfil all requirements. The result is that they are now placing on the market an instrument which is the only taximeter of British manufacture. Considering the success of this firm's older products, it would be quite safe to promise that this taximeter will not only oust foreign instruments from this country, but that it will be widely adopted in all countries where the motor-cab is introduced.

So far as the taximeter is concerned the makers in this case are quite on their own ground, for after all it is merely an advanced form of clock, and presents no great difficulties to the makers of such elaborate time-pieces as will indicate time intervals from seconds up to years, leap-years, and centuries, and which incidentally bring out mechanical singers and carols as each Christmas day comes round and a whole host of other ingenious novelties as the fad of the purchaser demands.

The "Smith" taximeter consists of a 14-day clock which is fitted with an auxiliary train of wheels giving readings on four indicating discs graduated in money values: the first showing amounts less than one shilling, the others indicating units, tens, and hundreds of shillings respectively. The fare-recording discs are thrown into and out of gear by the moving over of a lever to which is attached a flag indicating by its respective positions whether the cab is "Engaged" or "For Hire."

The motor-car and its phenomenal development appeal to all engineers; no apology need be offered our readers for the inclusion of this short description of a model engineering works and the motorists' specialities it produces.

Messrs. S. Smith & Son are widely known in the electrical world as the manufacturers of non-magnetic watches for the use of electricians, and, in fact, it is claimed that this firm were the pioneers of this highly specialised class of work.

Some Remarkable Cable Tests.

Johnson & Phillips, Ltd.

There are several makers of fireproof cables, but it is doubtful whether any of them would care to submit their products to the remarkably stringent fire tests which Messrs. Johnson & Phillips have publicly applied to their well-known Paterson cable.

On the 30th of last month there were assembled at the Old Charlton Works of the Company, many representatives of the leading engineering and technical journals who were one and all impressed with the series of unique cable fire tests shown them.

The principle of the Paterson cable is that of providing additional impregnated fireproof paper coverings, and also strong mechanical armouring to the ordinary rubber-insulated cable. The particular samples tested consisted in their coverings of: vulcanised rubber-braided insulation, over this a series of layers of Manila paper impregnated with fireproof fluid; on this is an armour of fine steel wires, further protected by more fireproof paper layers, a covering of impregnated jute, and a final coat of fireproof compound.

The essential part of these covers is undoubtedly the fine steel armouring, which is practically a woven braiding, giving extreme strength combined with flexibility. The particular feature of this method is that the steel covering prevents rupture of the covering by the expansion of internal heating, and moreover, insulates the cable core from external heating. As to how far this dual and complete protection has been attained is very obvious from the nature and results of the following tests, which were thoroughly made on the occasion mentioned.

Test No. 1.—Cable over Bunsen flame for half an hour, 220 volts maintained between steel protection and conductor as shown by incandescent lamp remaining lit. Afterwards hit sample with hammer and note effect.

The first part of the test left the cable apparently unaffected, the lamp remaining alight. Hammering the cable with 2lb. hand-hammer, three blows did not affect the insulation resistance, which remained at 75 megohms with 500 volts between conductor and armouring. At the sixth hammer blow the cable was quite flattened and short-circuited.

Test No. 2.—Cable over Bunsen flame as above, but not connected to electrical supply. Take insulation resistance between conductor and steel protection at intervals. Hit cable with hammer and again take insulation resistance.

The insulation tests showed, with 500 volts: 12 minutes, 70 megohms; 18 minutes, 75 megohms; and this latter value was maintained up to 40 minutes, the duration of the test. The sample then withstood a breakdown pressure test of 3000 volts.

Test No. 3.—Sample for this experiment is insulated and protected exactly as Paterson's fireproof cable, but an arc lamp carbon is substituted for the ordinary copper conductor; this carbon is broken in the middle and an arc maintained between the two portions with about 60amp.

This original test was the most striking and drastic of all. During the first few minutes of the current passing, the rubber insulation was volatilised and exuded from the ends of the samples. The cable became red-hot, but no flame ensued. The current was raised after 20 minutes to 90amp., but still no firing took place.

Test No. 4.—An internal arc as above is maintained in sample insulated as ordinary V.I.R. braided cable.

The effect of this test can be readily imagined. The sample exploded with loud report and burst into flame within a few seconds of the current being applied.

Test No. 5.—3/22's Paterson's fireproof cable conductor overloaded with 80-100 amps.

With this excessive overload the conductor fused in about two minutes, but the coverings were apparently unaffected.

Test No. 6.—3/22's insulated as ordinary V.I.R. braided cable. Conductor overloaded as in experiment No. 5. Note comparison.

In this case the conductor fused, and the entire sample burst into flame in less than two minutes.

After the above tests the visitors were afforded an opportunity of inspecting the Company's works. Of the many interesting devices more recently introduced by this

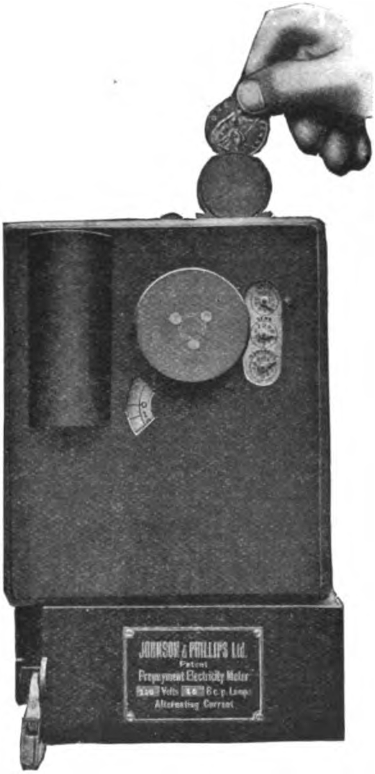

Fig. 1.
The J. & P. Penny-in-the-Slot Meter—Exterior View.

firm, there are two which merit particular attention. These are a penny-in-the-slot meter and an automatic time-actuated switch.

The J. & P. Prepayment Meter.

The new J. & P. penny-in-the-slot meter has been specially designed for use on those small installations where the load cannot exceed ten 8c.p. lamps.

The instrument consists essentially of a clock, a switch, and an ammeter. The coin is inserted in a novel trap and is only released to fall into the meter by depressing the side of the trap. A handle, projecting through the front of the case, cannot be turned unless the mechanism is released first by inserting a penny.

By inserting a coin, the mechanism is freed and allows the operator to wind: thus the clock is wound, the switch is put in circuit, and an epicyclic gearing is moved a certain distance for each coin inserted.

When the current is switched on, the clock mechanism is released by an electric magnet which clamps the balance wheel of the clock movement when no current is passing.

The clock is a regular time-keeper and revolves a snail which causes an arm to take up, at regular intervals of five minutes, a definite position against the aluminium scale of the ammeter, which position is governed by the current passing; the arm, having a greater or less movement, racks a small disc an exactly proportional distance; this disc, being directly connected to the epicyclic gearing spindle, moves the gearing in the opposite direction to that in which it was wound by the operator, and when the prepaid amount is used, the gear arm cuts out the switch.

The meter is very positive in its action; the switch at closing and opening has each pole separately actuated. The coin capacity of the meter is for coins up to the price of one unit of current—when these coins have been inserted a rigid guard covers the slot until a certain amount of current

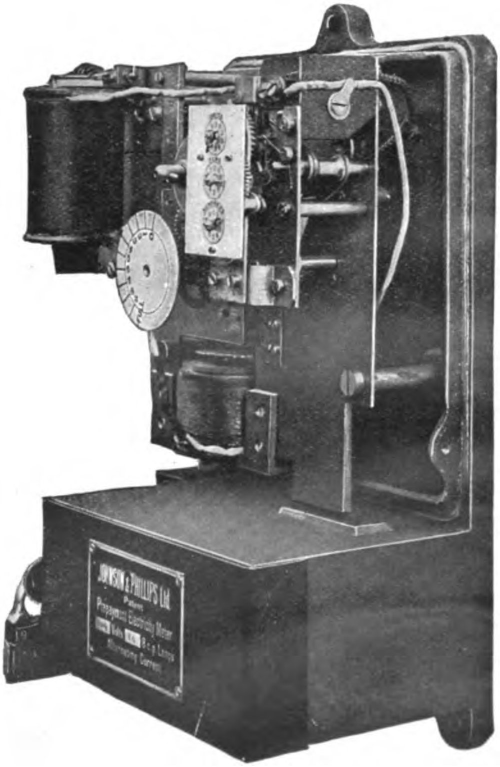

Fig. 2.
The J. & P. Penny-in-the-Slot Meter—Interior View.

has been used, when coins up to the maximum can again be inserted.

Changing from one price per unit to another is a very simple matter, consisting only of an exchange of change wheels.

The J. & P. Patent Time Switch.

The Johnson & Phillips time switch illustrated in Fig. 3 is claimed to be the only absolutely automatic time switch on the market. As will be seen, it is motor-actuated, and practice has proved it to be reliable and positive in its action.

The main switch is fitted with long carbon breaks, and is suitable for use up to currents of 60amp.

It can make and break the circuit at any predetermined time, and the alteration of the time for which the apparatus is to work can be made in a very simple manner.

The small motor, which is used for closing and for opening the switch, works for seven seconds when making and for two seconds when breaking the circuit. It is brought into action automatically, and having moved the switch in one direction or the other is stopped automatically. The motor also winds the clock every time it runs, the clock being fitted with a special spring arranged with a slipping device, so that it cannot be damaged by overwinding.

The face of the clock is engraved for 24 hours—12 hours a.m. and 12 hours p.m.—and revolves; behind the face are fitted horns, which are fitted hand friction-tight, so that they are placed easily in their right positions corresponding to the desired times of switch opening and closing. A screw is provided which, when tightened up, holds the horns securely in place.

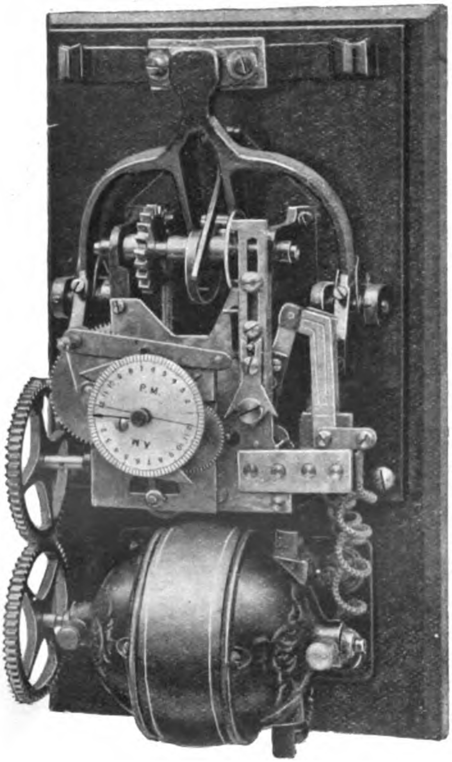

Fig. 3. The J. & P. Automatic Time Switch. Circuit Closed.

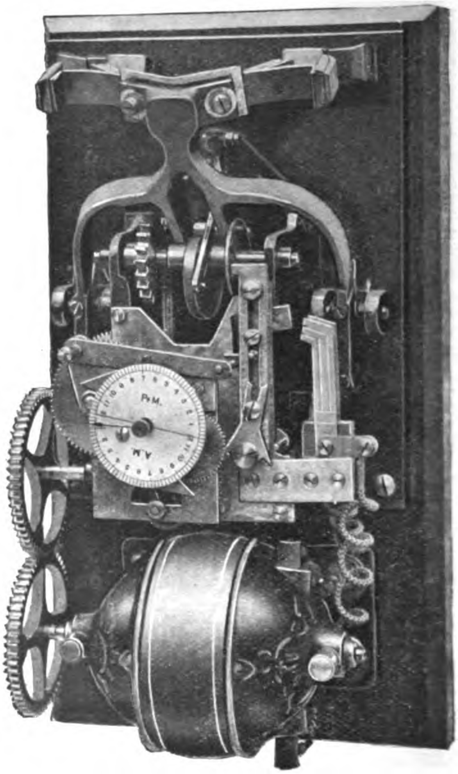

Fig. 4. The J. & P. Automatic Time Switch. Circuit Open.

◆

A Novel Table Fitting.

The "Peerless" self-contained standard fitting is designed to entirely eliminate the kinking and tangling tendencies of the usual flexible wire leads of portable fittings.

THE PEERLESS TABLE STANDARD FITTING.

In this case, the flexible cord is contained within the base of the standard lamp wound upon a very simple form of spring reel. As will be gathered from the illustration, the new type of table lamp is ornamental in appearance, and the addition of the novel mechanism in no way detracts from its graceful design. Any desired length of cord can be run out from the base of the standard; upon a release button being depressed the cord is again returned within the standard by the re-wind action of a spring. The contrivance operates like the usual spring tape-measure, and its simplicity insures reliability.

A wall fitting upon a similar principle is also included in the inventor's patent. The patentee is Mr. Arthur St. V. Burnaby, of Hove, Sussex.

New Catalogues, Trade Notices, &c.

Dynamos, Arc Lamps, &c.—UNION ELECTRIC COMPANY, LTD. The Company's new catalogue, No. 90, gives illustrated descriptions and prices of the principal electrical apparatus in which they specialise. These include the smaller sizes of dynamos and motors, "Koh-i-Noor" and "Excello" patent arc lamps, measuring instruments, switch-gear and auxiliary appliances. This is a very useful catalogue and will be found of particular service in that it also includes a list of the many other publications issued by the company.

Fan Motors.—BRITISH THOMSON-HOUSTON COMPANY, LTD. Pamphlet No. 203 describes a full list of direct and alternating current fan motors and exhaust fans. Various types are shown, some being for affixing to walls on brackets, others on table stands. A special type of wall exhaust fan is also described.

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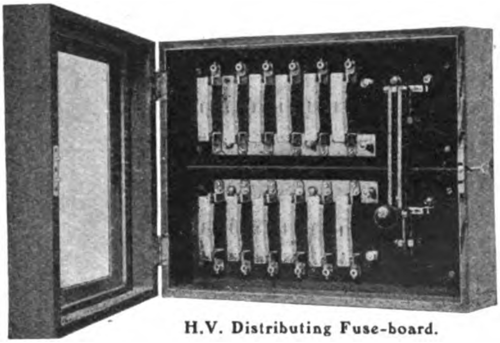

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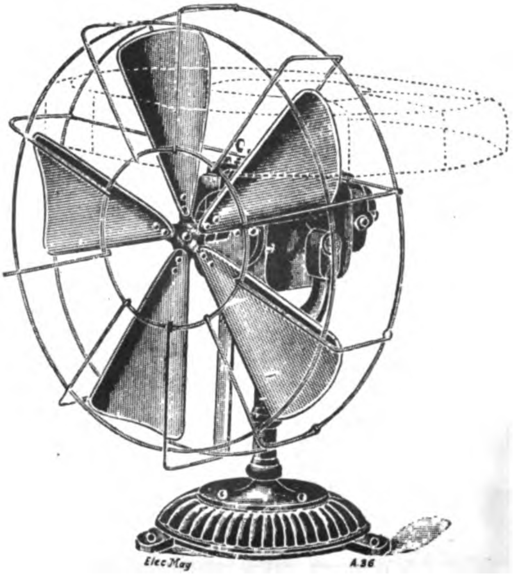

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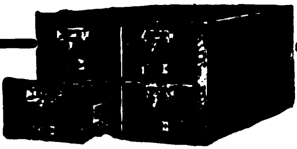

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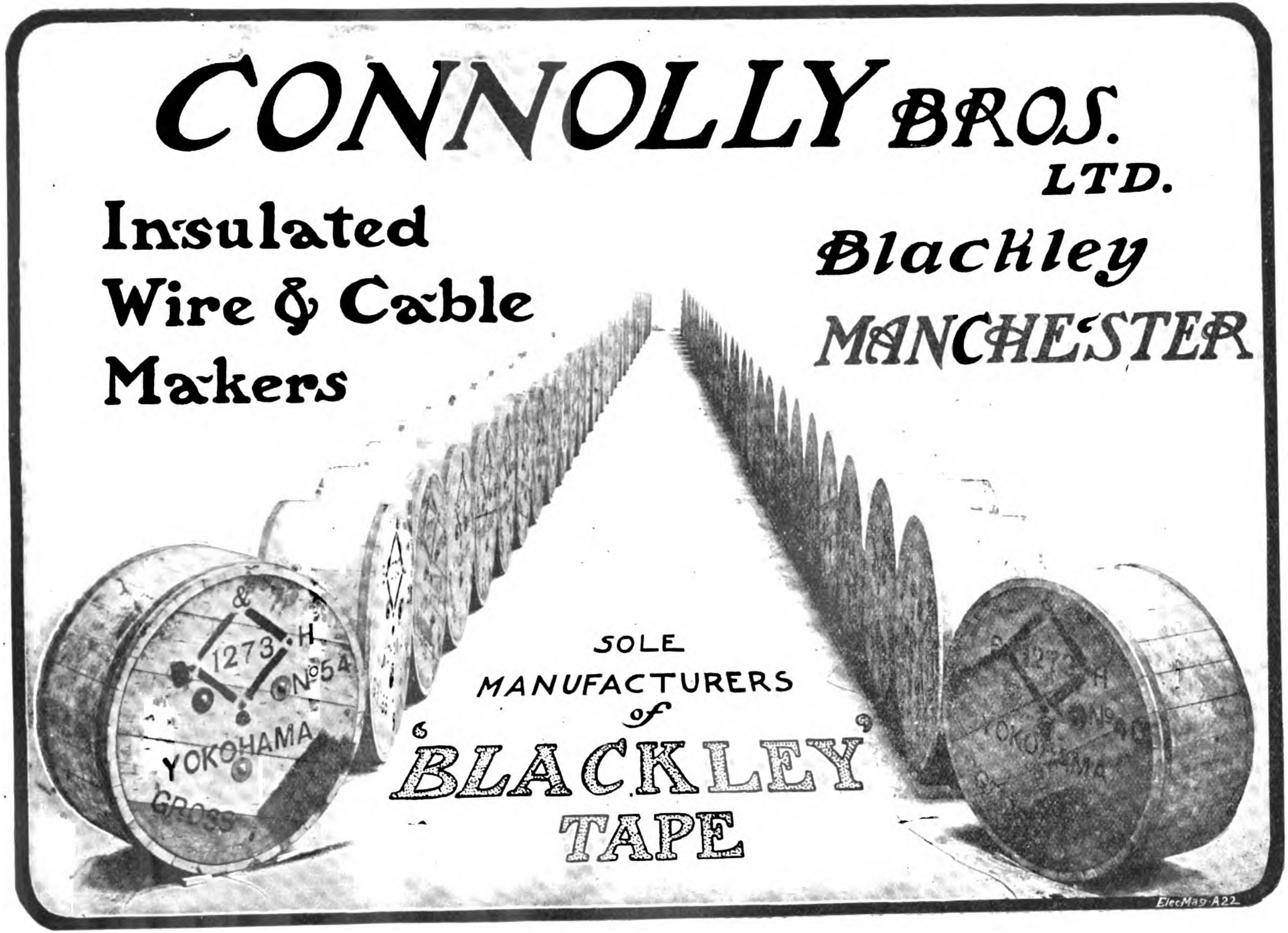

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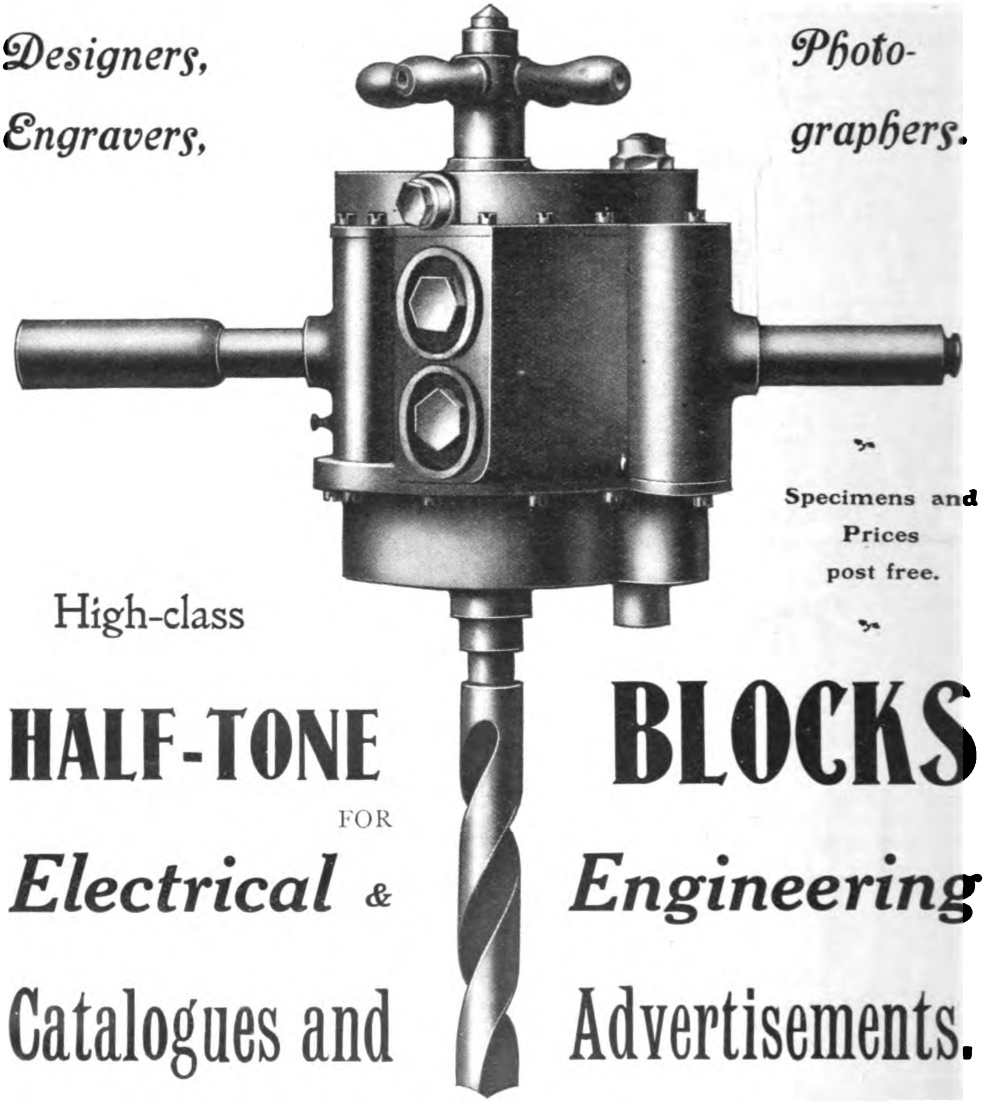

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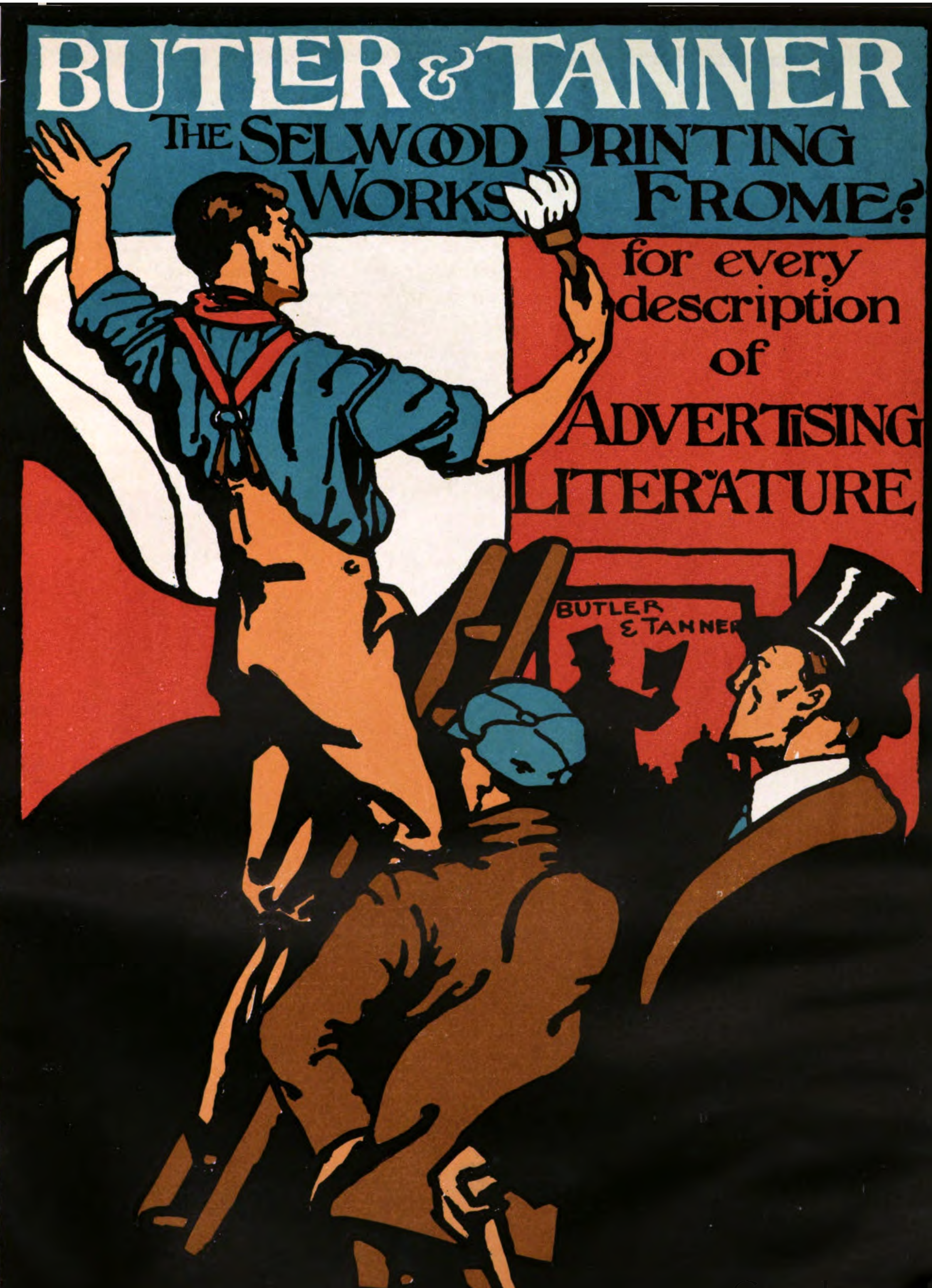
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